Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

1
Ec7Agr
c2

Agricultural Economics Research

Winter 1987 Vol. 39, No. 1

USDA
2010 OCT 18 A 12:

A Journal
of the
United States
Department of
Agriculture

Economic
Research
Service

1 The Exchange Rate and U.S. Agricultural Exports

13 Quarterly Livestock Sector Adjustments to Changes in Feed Grain Prices

25 Issues and Developments in Biotechnology: What's an Economist To Do?

34 U.S. Competitiveness in the World Economy

36 The Cult of Information

37 Breadlines Knee-Deep in Wheat: Food Assistance in the Great Depression

38 Food Policy: Frameworks for Analysis and Action

Agricultural Economics Research

A Journal of the U.S. Department of Agriculture • Economic Research Service

Editors	Judith Latham Gerald Schluter	Editorial Board	Terry Crawford Clark Edwards Roger Hexem
Assistant Editor	Lindsay Mann		William Kost Mindy Petrulis J. Michael Price Margaret Weidenhamer

Use of company names in this publication is for identification only and does not imply endorsement by the U.S. Department of Agriculture.

The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget, through March 31, 1987.

This periodical is published quarterly. Subscription rates are $13.00 domestic, $16.25 foreign. Send check or money order to (payable to Superintendent of Documents):

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

Microfiche copies are available from two different sources:

Congressional Information Service, Inc.
ATTN: Documents on Demand
P.O. Box 30056
Bethesda, MD 20014-0056

Issues for 1973 are available at $5.00 (for 2 fiche). Issues from 1974 on are available at $3.75 for the first fiche and $1.25 for each remaining fiche; they average 3 fiche per year.

UPDATA Publications, Inc.
1746 Westwood Blvd.
Los Angeles, CA 90024

Issues from 1949 on are available at $4.00 per issue.

In This Issue

This issue concludes my role as economics editor of *Agricultural Economics Research (AER).* When I started my editorship 3 years ago, I felt awed by the company I was joining. This journal has had an impressive group of editors. Gene Wunderlich, the incoming economics editor, will fit into this group well. I am sure he will maintain the level of excellence of my predecessors. I except my term because such evaluations of a journal editor are much like those of a plant or animal breeding experiment in that they succeed only if they make what comes after better. The real test will be if the group of articles from Volume 36, No. 2 (Spring 1984) through Volume 39, No. 1 (Winter 1987), influences the future literature of economics and agricultural economics.

The articles in volumes 34 (1982) and 35 (1983), edited by Clark Edwards and Lorna Aldrich, set impressive standards. The Social Science Citation Index (SSCI) uses the "impact factor," which measures the speed with which an article published in a journal has an impact on the literature, as one of its comparative indexes for computing a journal's value. The 34 citable items published here in 1982 and 1983 were cited eight times in 1984 in the source journals covered by SSCI. This 8:34 ratio (the "impact factor") places *Agricultural Economics Research* above most other agricultural economics journals and compares favorably with many of the well-respected economics journals in terms of immediate impact on the literature.

Together with ideas articulated by O.V. Wells in the first issue that this journal would be a vehicle for communicating how analysts in the Economic Research Service (ERS) do their work, the SSCI's "impact factor" provides a common theme for the three articles in this issue. First, if one were to select articles that would enhance the "impact factor" of a journal, one would choose articles on topics as timely as these: exchange rates and agricultural trade, the impact of the Food Security Act of 1985 on livestock sectors, and biotechnological impacts. These topics are surely relevant to the current policy agenda. Second, the three articles illustrate three separate approaches ERS takes in analyzing current policy. By their nature, current policy analyses have a time dimension that often precludes the formation of a separate research project to evaluate an issue. One must rely instead on the accumulated stock of past analyses.

These three articles illustrate three important approaches. First, ERS has devoted resources to developing a general economic model that can be used to analyze special situations. Second, when the real-world problem involves many economic actors and variables, the analyst may resort to algebraic analysis to ascertain underlying economic influences. Third, when confronting a new phenomenon for which prior experience is not available on which analysis can be based, the researcher must resort to descriptive analysis and informed speculation.

In the first article, Edwards uses a three-country trade model to explore the relevant issues in the current discussion about the importance of the recently strong dollar in explaining weak export demand for U.S. agricultural exports in the eighties.

In the second article, Westcott, Stillman, and Collins use the ERS quarterly commodity forecasting model to analyze the potential impact on livestock sectors of lower feed costs resulting from lower support prices in the Food Security Act of 1985.

In the third article, Offutt and Kuchler review and analyze issues in regulating biotechnology and analyzing the impact of potential innovations.

These articles allow me to conclude my tenure on a high point of relevance to current issues. I have appreciated the opportunity to edit this journal for the past 3 years. I thank the many authors, reviewers, and readers for their contributions and support.

Gerald Schluter

Contents

1 The Exchange Rate and U.S. Agricultural Exports
Clark Edwards

13 Quarterly Livestock Sector Adjustments to Changes in Feed Grain Prices
Paul C. Westcott, Richard P. Stillman, and Keith J. Collins

25 Issues and Developments in Biotechnology: What's an Economist To Do?
Susan E. Offutt and Fred Kuchler

Research Review

34 U.S. Competitiveness in the World Economy
Reviewed by Stephen W. Hiemstra

36 The Cult of Information
Reviewed by L. Joe Moffitt

37 Breadlines Knee-Deep in Wheat: Food Assistance in the Great Depression
Reviewed by Tom Fulton

38 Food Policy: Frameworks for Analysis and Action
Reviewed by Robert E. Christiansen

The Exchange Rate and U.S. Agricultural Exports

Clark Edwards

Abstract

An export slump is one of the major problems plaguing U.S. agriculture. Many of the world economic forces that had turned against U.S. farmers in the early eighties have now changed. The exchange rate is one of these forces. This article presents a simulation of the disparate impacts of depreciation on importers and competing exporters, and the implications for specifying price transmission equations in international trade models. Protective policies, such as tariffs and quotas, reduce the elasticity of exports with respect to a change in price.

Keywords

Exchange rates, exports, imports, agriculture, international, prices, trade, trade barriers

The volume of U.S. farm exports continues below its 1980 peak. This is one of the major problems plaguing agriculture. Lower exports contributed in the eighties to lower incomes, financial stress, and reduced values of land and other farm assets. Agriculture may not recover until farm exports pick up.

The export slump in the eighties followed an unusually rapid export expansion in the seventies. Changes in the world economic situation at the turn of the decade contributed to the slump. Slowed economic growth and reduced availability of foreign exchange reduced imports in many countries. A more expensive dollar and higher prices received by U.S. farmers added to the cost of importing U.S. farm products. Agricultural production increases in other countries either reduced demand for imports or increased supplies of competitive exports. High exchange rates were correlated with high domestic interest rates, so farmers were squeezed between reduced revenues and increased costs. High energy costs associated with the world energy situation added further to the squeeze. Subsequent reductions in energy costs were associated with losses of income and of foreign exchange for some importers of farm products. Changes in subsidies, tariffs, quotas, embargoes, and transportation rates added to the volatility of the decade.

The boom of the seventies was at an unsustainable rate of 8 percent per year. Many worried that the boom would stop because of limits to U.S. agricultural capacity. But the end came from the demand side instead, when the market collapsed for exports of U.S. farm products.

Many of the world economic forces that had turned against U.S. farmers by the early eighties have since changed, although they may be less favorable than they were during the early seventies. Reduced exchange rates and lower prices received by farmers relative to world levels suggest that conditions are now right for exports to begin to pick up. If they do, it will take U.S. agriculture a few years to absorb the resources idled during the export slump and to work off the accumulated surpluses. If they don't, U.S. agriculture can anticipate deepening financial troubles.

This article focuses on only one of several factors affecting the level of farm exports: price transmission. The key to price transmission is the exchange rate, but the mechanism is modified by institutional arrangements such as subsidies and tariffs. Relatively lower exchange rates were associated with the export boom of the seventies, and relatively higher ex-

---

The author is a senior economist with the National Economics Division, ERS.

change rates were associated with reduced exports in the eighties. The depreciation of the dollar in 1985 and 1986 could help expand exports.

The theory of equilibrium among three countries trading a single commodity is considered in the next section of this article. Currency realignments among competing exporters and importers have important, but disparate, economic effects on the various sources of supply and demand. The exchange rate theory is then used as a framework for evaluating some literature on exchange rates and agricultural exports. Both the theoretical and empirical approaches tend to agree that exchange rates are potentially important in explaining the variation in exports, but they tend to differ as to the magnitude of the change in exports with respect to a change in exchange rates. Finally, some implications are developed for specifying price transmission relationships in existing agricultural models and for reconciling some divergent views of the elasticity of response. The reconciliation entails allowances for tariffs, subsidies, and other institutional arrangements affecting price transmission.

Trade Equilibrium Among Two Exporters and One Importer

Consider a three-country world in which each country produces, consumes, and trades a homogeneous agricultural product under perfect competition. Such a model is as small as one can devise and still simulate the impacts of exogenous changes in the exchange rates of an exporting country on its own exports and also on production, consumption, and trade of an importer and a competing exporter. Variables in the model are the quantity produced, the quantity consumed, and the price in each country—nine variables in all.

There are three demand equations, one for each country. For simplicity, let them be linear:

$$p_j = \alpha_j - \beta_j \, qd_j \qquad \text{for } j = 1 \text{ to } 3$$

And there are three linear supply equations:

$$p_j = \mu_j + \sigma_j \, qs_j \qquad \text{for } j = 1 \text{ to } 3$$

where p, qd, and qs are the prices, quantities demanded, and quantities supplied; α, β, μ, and σ are parameters for the demand and supply equations; and j is an index for countries.

Trade among countries requires two transactions, one related to the exchange among goods and the other to the exchange among currencies. In this model, the terms of trade among goods are endogenous and the terms among currencies are exogenous. Let the symbol r_j represent the exogenous exchange rate between the first and the j^{th} country. Then two of the price relationships are:

$$p_1 = r_j \, p_j \qquad \text{for } j = 2 \text{ to } 3$$

An increase in r_j reflects a depreciation in the currency of country 1. In empirical work it is important whether the exchange rate measures foreign currency per unit of domestic currency or domestic currency per unit of foreign currency. For the purposes of a hypothetical simulation, this ambiguity is not important. These two price transmission equations imply a third redundant equation:

$$p_2 = (r_3 \div r_2) \, p_3$$

This simplest form of the price transmission equations is used in the theoretical simulation. The review of literature to follow shows that modifications reflecting institutional arrangements such as tariffs and transportation are important. Such modifications will be discussed later.

The final equation assures that the market clears. Many trade models require that the sum of the exports by the exporting countries equals the sum of the imports by the importing countries. This restriction has the same effect as requiring that the sum of demands in all countries equals the sum of supplies. The latter formulation was chosen because it is easier to track things if some of the shocks to the model cause one of the countries to switch from, for example, an exporter to an importer. In conjunction with the other equations, the final equation assures that market-clearing prices are found:

$$\Sigma \, qd_j = \Sigma \, qs_j \qquad \text{for } j = 1 \text{ to } 3$$

The model presented here and the hypothetical data used to implement it help organize ideas, evaluate the literature, and suggest specifications for more detailed and empirical models. This model brings out salient relationships between exports and exchange rates with a minimum of conceptual framework. It omits facets of exchange that are important in real-world trade while highlighting the disparate impacts of exchange rate fluctuations on the various sources of demand and supply.

Taking exchange rates as exogenous in a one-commodity world overlooks important problems facing world trade since exchange rates began to float in the early seventies. Orden, for example, explains exchange rates by income transfers among countries resulting from trade surpluses and deficits in a multicommodity framework (*17*).[1] Other real-world relationships not considered here include monetary matters and the distinction between shortrun and longrun responses. See Chambers (*4*), for example, for a broader perspective than that taken here, including endogenous changes in exchange rates and the relationship to agriculture of monetary phenomena other than exchange rates. A more complete model specification and careful statistical estimation of the structure are beyond the purpose of this article, although the analysis and review suggest how such model building and estimation might be done.

Sensitivity to Exchange Rates

The small and linear system presented here is relatively easy to solve. Consider a reduction of the model to two equations and two unknowns. Let the unknowns be the quantity supplied in country 1 and the price in country 1. One of the equations is the original supply function for country 1:

$$p_1 = \mu_1 + \sigma_1 qs_1$$

The other equation is found by the substitution of the other seven demand and supply functions into the market-clearing equation. The resulting relation, solved for qs_1 as a function of p_1, captures the net demand for the quantity produced in country 1:

$$qs_1 = \left[\frac{\alpha_1}{\beta_1} + \left(\frac{\alpha_2}{\beta_2} + \frac{\mu_2}{\sigma_2}\right) + \left(\frac{\alpha_3}{\beta_3} + \frac{\mu_3}{\sigma_3}\right)\right] - \left[\frac{1}{\beta_1} + \left(\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right)\left(\frac{1}{r_2}\right) + \left(\frac{1}{\beta_3} + \frac{1}{\sigma_3}\right)\left(\frac{1}{r_3}\right)\right] p_1$$

This linear and downward sloping equation contains the parameters of the other seven demand and supply functions. Econometricians frequently use the term "demand function" to denote quantity as a function of price and use the term "inverse demand function" to denote price as a function of quantity. The qualifier "inverse" is dropped in this article, although both forms of the function appear. However, understanding the distinction is important in interpreting the various relations discussed because an increase in the slope of a demand curve, for example, is a decrease in the slope of the inverse demand curve.

An increase in the demand in a foreign country or a decrease in the supply increases the demand for the product of country 1. Devaluation of the currency of country 1 also increases demand. The individual exchange rates enter the demand equation as a weighted harmonic mean, where the weights are functions of the slopes of the various demand and supply curves; the flatter the slope, the heavier the weight. This weighting scheme is different from that usually encountered in an index of exchange rates.

A change in the demand for the production of country 1 with respect to a change in an exchange rate is described by the partial derivatives:

$$\frac{\delta\, qs_1}{\delta\, r_2} = -\left[\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right]\frac{p_1}{r_2^2}$$

and:

$$\frac{\delta\, qs_1}{\delta\, r_3} = -\left[\frac{1}{\beta_3} + \frac{1}{\sigma_3}\right]\frac{p_1}{r_3^2}$$

As an exchange rate increases (r_j increases), the currency of country 1 depreciates and the quantity demanded increases; the increase is a function of the price, exchange rate, and the slopes of these supply and demand curves in the foreign country. These derivatives are incorporated into the definitions of elasticity of the quantity demanded of country 1 with respect to either exchange rate. For example, the exchange rate elasticity of demand with respect to country 2 is:

$$\text{elasticity} = -\left[\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right]\frac{p_2}{q_1}$$

A complete symbolic solution of the nine-equation model should be instructive and not too difficult. Yet it is sometimes easier to get a feel for the interaction among equations—that is, for how a change in one exogenous parameter affects all the endogenous variables simultaneously—by means of a simulation. The partial elasticities just discussed do not give the flavor which total elasticities do by reflecting feedbacks from other relationships in the system.

The nine-equation, three-country trade model was calibrated to produce the base scenario listed in the first column of table 1. Prices in all three countries equal unity, demands equal 100 units of the homogenous commodity, and supplies are such that countries 1 and 2 each export 10 units to country 3.

The parameters to produce the base scenario were chosen to incorporate the following structural properties: the price elasticities of demand at the initial equilibrium are 0.5 in each of the three countries and the price elasticities of supply are 1.0. The parameters are:

---

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

$$\left.\begin{aligned}\alpha_j &= 3.0000\\ \beta_j &= 0.0200\\ \mu_j &= 0.0000\end{aligned}\right\} \quad \text{for } j = 1, 2, 3.$$

$$\sigma_1 = 0.0091$$
$$\sigma_2 = 0.0091$$
$$\sigma_3 = 0.0125$$

The chart shows the trade balance among the three countries. The chart is not drawn to scale. The chart and the logic underlying the model are taken from Kost (*13*); also see (*1*). Panels A, C, and E show the domestic supplies and demands; panels B and D show price transmission. The solid price line traces equilibrium production, consumption, exports, and imports when all three prices are equal and all exchange rates are unity, as in the base scenario, column 1, table 1. The dotted price line traces trade equilibrium under devaluation by country 1 against the other two countries, as in column 4, table 1.

Devaluation need not apply against all other currencies simultaneously. A country's currency may devalue against one country while holding constant with others. Consider three cases: a devaluation by country 1, an exporter, first against the other exporter; second, against the importer; and finally, against both concurrently.

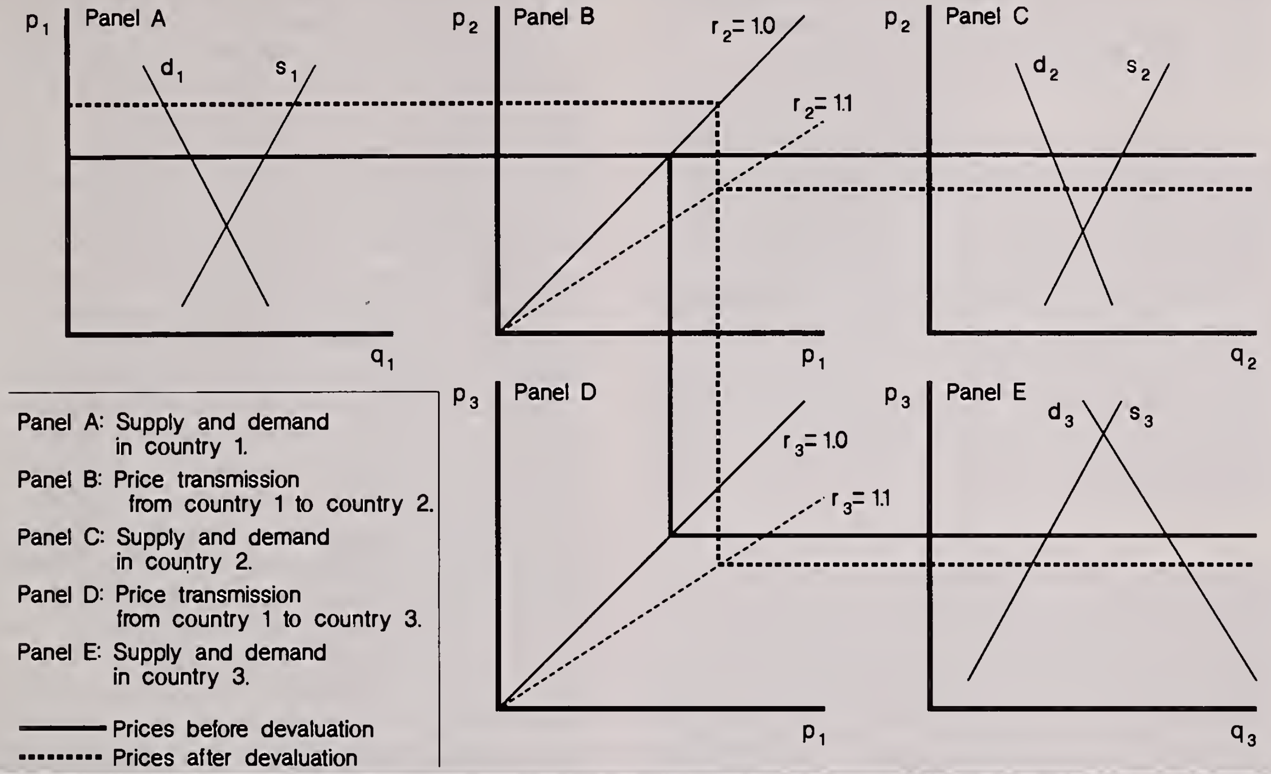
The effects of a 10-percent devaluation by country 1 against the other exporter (country 2) are reported in column 2 of table 1. This situation would result if the United States devalued against other exporters of farm products while the values of the currencies of importers were tied to the dollar. The exchange rate r_2 was set at 1.1, but r_3 remained at 1.0. The devaluation lowers prices in country 2, the other exporting country. This situaton is not explicit in the chart, but it can be followed there. Note where the solid price line from panel A projects to the 45-degree line in panel B. Drop straight down to the dashed line in panel B, where p_2 is 90 percent of p_1. From this intersection, project p_2 to panel C to see how the devaluation lowers the price in country 2, reduces production, and increases consumption. Their exports are reduced. Reduced world production boosts world prices, which stimulates production in countries 1 and 3 and decreases consumption there. Prices in country 2 are subsequently boosted also, so the equilibrium decrease in that country is less than the initial drop. Suppliers in the country against which the devaluation took place are worse off, but consumers in that country are better off as they are paying less to consume more. Suppliers in the country that devalued are better off, and so are suppliers in the importing country. Exports of country 1 increase 53 percent, implying a total elasticity

Table 1—Supply and demand responses to exogenous changes in the exchange rates, three-country model

Economic variable[1]	Base scenario	$r_2 = 1.1$ $r_3 = 1.0$	$r_2 = 1.0$ $r_3 = 1.1$	$r_2 = 1.1$ $r_3 = 1.1$
		Units		
Country 1:				
p_1	1.00	1.0334	1.0270	1.0622
qd_1	100.00	98.3299	98.6515	96.8884
qs_1	110.00	113.6743	112.9668	116.8455
Exports	10.00	15.3445	14.3154	19.9571
Country 2:				
p_2	1.00	.9395	1.0270	.9657
qd_2	100.00	103.0271	98.6515	101.7167
qs_2	110.00	103.3403	112.9668	106.2232
Exports	10.00	.3132	14.3154	4.5064
Country 3:				
p_3	1.00	1.0334	.9336	.9657
qd_3	100.00	98.3299	103.3195	101.7167
qs_3	80.00	82.6722	74.6888	77.2532
Exports	−20.00	−15.6576	−28.6307	−24.4635

[1] p = price; qd = quantity demanded; qs = quantity supplied; and exports = qs − qd.

Effect of a Devaluation by an Exporting Country on an Importer and a Competing Exporter


Panel A
p_1
d_1
s_1
q_1
Panel B
p_2
r_2= 1.0
r_2= 1.1
p_1
Panel C
p_2
d_2
s_2
q_2
Panel D
p_3
r_3= 1.0
r_3= 1.1
p_1
Panel E
p_3
d_3
s_3
q_3
Panel A: Supply and demand in country 1.
Panel B: Price transmission from country 1 to country 2.
Panel C: Supply and demand in country 2.
Panel D: Price transmission from country 1 to country 3.
Panel E: Supply and demand in country 3.
Prices before devaluation
Prices after devaluation

of about 5. Consumers are worse off in countries 1 and 3 because they are paying higher prices to consume less. World consumption declines slightly in this example.

The effects of a 10-percent devaluaton by country 1 against the importer (country 3) are reported in column 3 of table 1. This situation would result if the currencies of competing exporters, such as Canada, fell about in line with the dollar as the dollar depreciated relative to the currencies of importers, such as Japan. The exchange rate r_3 was set at 1.1, but r_2 remained at 1.0. The devaluation lowers prices in the importing country (country 3). Note where the solid price line from panel A projects down-ward from the 45-degree line in panel B to the 45-degree line in panel D. Continue straight down to the dashed line which represents a 10-percent devaluation against country 3. From this intersection, project p_3 to panel E (this projection is not shown in the chart) to see how the devaluation initially lowers the price, reduces production, and increases consumption in country 3, so imports are increased. The expansion in world consumption boosts world prices. The price increase stimulates production in the two exporting countries and decreases consumption there. Exports of country 1 increase 43 percent. Prices in country 3 are subsequently boosted also, so the equilibrium decrease is less than the initial drop. Suppliers in the importing country are worse off because they are selling less at lower prices, but consumers there are better off because they are paying less to consume more. Suppliers in the country that devalued are better off, and so are the suppliers in the other exporting country. Consumers are worse off in both exporting countries because they are paying more to consume less. Total world consumption increases slightly in this example.

The effects of a 10-percent devaluation by country 1 against both other countries are reported in column 4 of table 1. Uniform devaluation is often assumed in theory, but the review of literature later in this article indicates that it may seldom obtain in practice. The dashed line traces out production, consumption, and trade in equilibrium after the uniform devaluation. The devaluation against both countries improves the position of farmers in the devaluing country, but worsens the position of consumers there. Lower prices in the other countries help consumers there, but hurt farmers. The importing country increases its imports and shifts its source of imports toward the devaluing country. The other exporter loses some of its markets. The devaluing country about doubles its exports, partly because of increased imports by the deficit food producer and partly because it captures some of the market of the other surplus food producer.

An exogenous change in an exchange rate changes one pair of relative prices. Subsequent demand and supply response induces changes in other relative prices. If one could predict the equilibrium prices that would result from a depreciation, then one could predict from the various supply and demand elasticities what the changes in production, consumption, and trade would be. The more elastic the supply in the devaluing country, the less will be the changes in other relative prices subsequent to the devaluation and, therefore, the easier it is to predict equilibrium prices.

In the example, the three price elasticities of demand underlying table 1 are 0.5, and the three price elasticities of supply are 1.0. Therefore, the initial effect of a 10-percent devaluation is a 10-percent reduction in supply in the affected country and a 5-percent increase in demand. Of course, the trick to using this information is to know what the system equilibrium price effects will be. For the general case, one needs a model, such as we have here, that predicts the equilibrium prices and quantities. The devaluation against the other exporter added 5.3 units to exports, and the devaluation against the importer added 4.3 units. These separate effects almost add up to the 10.0 units added by the uniform devaluation. Had the price elasticity of supply in country 1 been greater (it is 1.0 in the example), the price response to changing world production and consumption would have been less, and the separate effects would have come even closer to adding up to the total effects. On the other hand, a more inelastic supply in the devaluing country would have increased the ensuing price response and created a larger difference between the separate and total effects.

So, except in special cases, knowing that one can predict final quantities if one knows final prices is not very useful. The important and practical exception is: If the devaluing country is a residual supplier into world markets (that is, if that country's export supply function is perfectly elastic), then the resulting changes of a devaluation on consumption, production, and trade can be estimated from a knowledge of supply and demand elasticities in the affected countries.

Trade Equilibrium When One Country is a Residual Supplier

The United States has been characterized as a residual supplier of grains in world trade. One way to describe a residual supplier is that the country stands ready to export an indefinitely large quantity in response to a small increase in the world price; that is, the country has a perfectly elastic export supply function. Another way to characterize the same phenomenon is that all other countries trade at the world price, and then the residual supplier fills in the gap between total exports and total imports at the world price. We can model country 1 as a residual supplier by making an extreme assumption that p_1 equals 1.0 and by dropping country 1's supply function from the model. In this eight-equation version of the model, country 1's price is exogenous and country 1's supply is determined as a residual in the balance equation that sets world production equal to world consumption. The base scenario in column 1 of table 2 is the same as the base scenario in table 1. The parameters remain as before (see page 4).

The effects of a 10-percent devaluation by the residual supplier against the other exporting country, country 2, are reported in column 2 of table 2. The price received by farmers in the other exporting country drops in accordance with the price transmission equation; it remains at the new, lower level as supply and demand adjust to the exogenous change in relative prices. Supply decreases in accordance with the price elasticity of supply, and demand increases in accordance with the price elasticity of demand. Exports drop; in fact, in this example, country 2 switched from an exporting country to an importing country. No changes take place in the importing country (country 3) because its price does not change. The residual supplier expands shipments to replace those lost by the other exporter; this is export supply substitution with a vengeance. Suppliers in the devaluing country gain through increased sales at the same price. Consumers in the country against which the devaluation was taken gain through increased consumption at a lower price, but suppliers there lose from reduced sales at a lower price. There are no welfare changes for consumers in countries 1 and 3 or for farmers in country 3. Total world consumption is increased.

The effects of a 10-percent devaluation by the residual supplier against the importing country (country 3) are in column 3 of table 2. Country 3's price drops, production decreases, consumption increases, and the difference is met by the residual supplier. Farmers in the devaluing country gain, as do consumers in the importing country. Farmers in the importing country sell less at lower prices. Consumers in the devaluing country and both consumers and farmers in the other exporting country have no changes in welfare. Total world consumption is increased.

The effects of a 10-percent devaluation by the residual supplier against both the importing and exporting countries are in column 4 of table 2. The increase in exports associated with devaluing against the other exporter plus the increase associated with devaluing against the importer add precisely to the increase in exports for the uniform devaluation. This result would not hold precisely, but might hold approximately if the price of the residual supplier were permitted to vary a little.

If the devaluing country is a residual supplier and if the price transmission equations are known, one can calculate from the appropriate elasticities of demand and supply the consequences of a depreciating currency on production, consumption, and trade separately for each affected country and then sum the results.

The theoretical discussion indicates the equity and efficiency implications of fluctuating exchange rates. Price and exchange rate elasticities of demand for exports can be high even though domestic demands in individual countries are inelastic. The model reveals the complicated structure of an equation which expresses net demands for a commodity in terms of foreign demands, supplies, and exchange rates. The discussion now turns to selected literature on the role of exchange rates and price transmission in agricultural exports.

The Responsiveness to Depreciation: Price Transmission

The dollar began to float relative to other currencies in 1971 and 1973, after an extended period of fixed exchange rates. The fluctuation in exchange rates was accompanied by changes in prices and exports. Schuh noted that analyses of trade had, through the early seventies, neglected exchange rates (*18*). Under the assumption that the net export demand for farm products is highly elastic, Schuh concluded that the depreciation of the dollar in 1971 and in 1973-74 contributed importantly to the increase in prices received by farmers and to the increase in exports.

Theoretical models of competitive trade equilibrium tend to suggest that exports are elastic with respect to depreciation, as Schuh assumed. In the example (tables 1 and 2), a 10-percent devaluation increased exports 50-150 percent. Bredahl and Gallagher concluded that "the percentage change in quantity traded due to an exchange rate change may be quite large" (*1*). Some empirical work supports these large responses. Chambers and Just found that a 10-percent depreciation resulted in shipments of 91 percent more corn, 34 percent more wheat,

Table 2—Supply and demand responses when the devaluing country is a residual supplier

Economic variable[1]	Base scenario	$r_2 = 1.1$ $r_3 = 1.0$	$r_2 = 1.0$ $r_3 = 1.1$	$r_2 = 1.1$ $r_3 = 1.1$
		Units		
Country 1:				
p_1	1.00	1.0000	1.0000	1.0000
qd_1	100.00	100.0000	100.0000	100.0000
qs_1	110.00	124.5455	121.8182	136.3636
Exports	10.00	24.5455	21.8182	36.3636
Country 2:				
p_2	1.00	.9091	1.0000	0.9091
qd_2	100.00	104.5455	100.0000	104.5455
qs_2	110.00	100.0000	110.0000	100.0000
Exports	10.00	−4.5455	10.0000	−4.5455
Country 3:				
p_3	1.00	1.0000	.9091	.9091
qd_3	100.00	100.0000	104.5455	104.5455
qs_3	80.00	80.0000	72.7273	72.7273
Exports	−20.00	−20.0000	−31.8182	−31.8182

[1] p = price; qd = quantity demanded; qs = quantity supplied; and exports = qs − qd.

and 8 percent more soybeans while reducing domestic use by 21, 2, and 4 percent, respectively (*5*).

Other empirical work suggests that the impact of exchange rate fluctuation is small. Greenshields found that changes in exchange rates between the Japanese yen and the currencies of Japan's major suppliers of wheat, corn, sorghum, and soybeans had little effect on U.S. grain and soybean exports to Japan (*10*). Greenshields' assumptions differ from Schuh's. Schuh assumed a perfectly elastic export demand and an inelastic export supply; Greenshields assumed a perfectly elastic export supply, as assumed in table 2. Schuh's assumption puts most of the impact of depreciation on price; Greenshields' puts most of it on quantity. Even so, Greenshields found little difference between the actual quantities exchanged after the depreciation and what one might have expected had exchange rates not changed. He attributed the trade stability to protective institutional arrangements such as determinations by the Japanese of how much will be imported each year.

Vellianitis-Fidas did a cross-sectional analysis for 1971-73 and a time series analysis for 1954-69, when the U.S. dollar was relatively stable, but important depreciations and appreciations occasionally occurred (*19*). The studies exhibited no relationships not explained by extenuating circumstances; "the change in the exchange rate of the United States, a major supplier of agricultural commodities on the world market, did not significantly affect agricultural trade" (*19*). Johnson, Grennes, and Thursby found that the dollar depreciation in 1973-74 was less important than price-insulating policies by other major importers and exporters in explaining price movements (*12*). Jabara found that response to exchange rates was inelastic, but noted that aggregated models mislead; wheat-producing countries had a different response than nonproducing countries had (*11*).

Numerous studies indicate that, although the impacts of depreciation are less than indicated by theoretical, competitive, trade equilibrium models such as described here, the effects can be substantial. The simplified models of trade apparently omit real-world factors that tend to damp price transmission. The limits to using price to explain quantity is common in the empirical literature of economics, whereas theoretical models continue to emphasize the price-quantity relation. Among the omitted factors are trade restrictions (*3*) and price insulation (*2, 15*). Collins, Meyers, and Bredahl find both substantive and procedural explanations (*7*). Among their substantive explanations, they find that the impact of depreciation varies with the crop examined, the year observed, the country involved, the economic structure (represented by the various demand and supply elasticities), relative rates of inflation, and government policies in importing and exporting countries. Among their procedural explanations, Collins, Meyers, and Bredahl find that estimates of impact vary with whether the price used in analysis is real or nominal, with what opportunity costs are explicitly recognized, and even with the definition of "exchange rate effect." Meyers examined alternate ways to specify exchange rate models and showed that different specifications result in different estimates (*15*).

Longmire and Morey used trade-weighted, inflation-adjusted prices and exchange rates by commodity to assess the effects of a change in the price of a dollar on agricultural exports (*14*). They estimated that a 20-percent depreciation (appreciation) would raise (lower) exports of wheat, corn, and soybeans by about 16 percent.

The commodity export demand equations used in the Economic Research Service's forecasting model called FAPSIM adjust prices using the Special Drawing Rights (SDR) exchange rate. The price elasticities of export demand for wheat and corn are 0.5 and 0.4, respectively. That is, a 20-percent depreciation would increase corn exports by 10-percent and wheat exports by 8 percent.

Linear Price Transmission

Price transmission among countries was modeled as:

$$p_1 = r_j \, p_j$$

When r_j is 1.0, prices are the same in both countries. When country 1 devalues 10 percent, r_j is 1.1 and p_1 is 10 percent above p_j. The review of literature suggests a need to modify this equation. Tariffs, subsidies, variable import levies, quotas, licenses, transportation regulations, high marketing margins, commodity-specific exchange rates, pegged exchange rates, and other policies affecting the price transmission equation complicate the simple model used here. For example, if protection is implemented between countries 1 and 2, but not between countries 1 and 3, price transmission between countries 2 and 3 changes. A devaluation by country 1 and a revaluation by country 2 are not symmetrical because of the differential effects on country 3 (see *2*).

Coyle, Chambers, and Schmitz reviewed recent theoretical and empirical research on the economic gains from international trade, particularly agricultural trade (*8*). They found that the traditional arguments concerning the equity and efficiency of free trade are easily violated under a variety of circumstances. Some of their findings can be reflected by transformations of the price transmission equations. Consider linear transformations first, and then nonlinear ones.

Suppose that country 1 subsidizes exports. A subsidy would drive the price down in country j, just as a devaluation would. A tariff by country 1 on its own exports would raise the price to others, just as an appreciation would. Tariffs and subsidies are like multiple exchange rates, except that they are usually by commodity and exchange rates are usually by country. The review of literature indicates that commodity detail may be as important as regional detail, but the model used here assumes only a single commodity. Let s be 1 plus the subsidy rate minus the tariff rate. When there is no tariff or subsidy, $s = 1$ and there is no action. A subsidy of 10 percent increases s to 1.1, and a tariff of 10 percent decreases it to 0.9. The modified price transmission equation is:

$$p_1 = r_j s_j p_j$$

If a subsidy or tariff were imposed by volume of trade, say per bushel or per ton, instead of as a percentage of price, then the modification of the price transmission equation is additive instead of multiplicative. Let S be positive for a per-unit subsidy and negative for a per-unit tariff or transportation charge. Then the price transmission equation which accounts for both additive and multiplicative policy changes is:

$$p_1 = S_j + r_j s_j p_j$$

Policies implemented by country 1 that stretch or shrink the price, such as *ad valorem* taxes, or that affect costs per ton or bushel, such as transportation differentials, can be modeled as linear transformations on the price transmission equation. The general form of the price transmission equation is:

$$p_1 = \pi_j + \phi_j (r_j p_j)$$

where π and ϕ are to be determined by empirical analysis. If one can assume that the policy structure is constant during a sample period, one can then use regression analysis to estimate the two parameters. (However, one must decide which way causality runs when doing these regressions.) The discussion related to tables 1 and 2 assumed $\pi = o$ and $\phi = 1$ and found a highly elastic response to depreciation. If ϕ is less than unity, or π is less than zero, the price transmission under depreciation will be damp, and the export response will be more inelastic. Protective tariffs and high transportation costs damp elasticities.

Meyers, Gerber, and Bredahl estimated linear transformations of price transmission to account for price insulation by the importing country (*16*). They found the elasticity between the Japanese and U.S. price to be 0.99 for soybeans, 0.85 for corn, and 0.77 for soybean meal. For wheat and rice, where price insulation inhibited transmission, they concluded that the elasticity was zero.

Meyers discusses appropriate ways to specify the exchange rate in estimating a transmission equation; he recommends converting all values—including demand shifters such as income per capita—to real, base year, base country values (*15*).

The choice of which exchange rate to use in empirical work is important. Dutton and Grennes examined alternative measures of effective exchange rates appropriate for agricultural trade analysis (*9*). They found that the proper measurement of the exchange rate variable may be as important as accurate measurement of parameters in a model. For example, the Special Drawing Right (SDR) can be misleading because the dollar is an important part of the SDR basket of currencies and because the SDR uses a different weighting scheme than some of the other indicators. Dutton and Grennes found it surprising how much different indexes, "all purporting to measure the same thing, differ among themselves" (*9*, p. 25).

Nonlinear Price Transmission

Some policies affect price transformations in a nonlinear way. Examples are: price support programs, income tax laws, imperfect competition, and nontariff barriers. Collins estimated equations for the transmission of corn, wheat, and soybean prices at U.S. gulf ports to 47 countries (*6*). The equation was of the form:

$$p_j = a\, r_j^b\, p_1^c$$

Where a, b, and c are parameters estimated by regression analysis, and p_1 is the U.S. gulf port price. These parameters were each assumed equal to unity in tables 1 and 2. Non-unity values imply imperfections in price transmission. Note that Collins' equation puts the j^th^ country's price on the left side. For the purposes of pure theory and when the three regression parameters are set equal to unity, this switch makes no difference, other than that Collins' exchange rate (r) is the reciprocal of the one used here. The switch is important in reflecting assumptions about the direction of causality in the regression analysis. Moreover, non-unity values for the elasticities of transmission, b and c, can cause differences in interpretation when the equation is switched. If c is estimated as close to zero and then the Collins equation is solved for p_1, the elasticity associated with p_j, $1 \div c$, will approach infinity. If the Cobb-Douglas functional form is used to estimate price transmission, it is important which direction of causality is assumed when the elasticities differ significantly from unity. This is not a problem with linear price transmission equations.

Collins' findings are summarized in table 3. The modal exchange rate elasticity is unity for each of the crops examined. However, 36 percent of the wheat exchange rate elasticities are between 0 and 1, and 36 percent of the corn exchange rate elasticities are close to zero. The modal price elasticity is significantly less than unity and greater than zero for each crop. There is a greater degree of imperfection in the price transmission than in the exchange rate transmission.

Collins' findings support the suggestion of other empirical research that the responses to changes in exchange rates need not be nearly as elastic as implied in the theoretical model examined in this article. Price and exchange rate transmission varies by crop and by country. The rates depend on factors such as tariffs, subsidies, transportation costs, embargoes, quotas, marketing margins, relative rates of inflation, and other institutional arrangements and market imperfections.

Implications

This review raises empirical questions that the model presented here cannot answer. Even so, the empirical difficulties of incorporating appropriate price transmission relationships into existing and complex models of U.S. agriculture are not insurmountable. One could, for example, add a net trade module to an existing domestic model, where the trade module reflects supplies, demands, and price transmission in sufficient commodity and regional detail. Or one could concentrate on specification of the export equations in an existing model. Recall that the nine-equation model was solved for the demand for the production of country 1 as a function of price and of the various parameters of the model. Careful examination of the subscripts of that equation reveals that demand for the total production of country 1 is the sum of domestic demand and the two net foreign demands.

Table 3—Price and exchange rate transmission elasticities

Elasticity	Wheat		Corn		Soybeans	
	Price	Rate	Price	Rate	Price	Rate
	Number of countries					
Not significantly different from 1	5	17	10	17	3	8
Between 0 and 1	22	11	18	4	6	2
Not significantly different from 0	3	2	5	12	1	0

To focus on the demand for exports, consider instead a three-equation version of the model which includes the supply and demand curves for country 1 and net demand for the exports of country 1. The literature review suggested that proportional tariffs and subsidies (s) and per-unit tariffs and subsidies (S) will modify the price transmission equations and will thereby affect the demand for exports. When s and S are included, the demand relation associated with net exports of country 1 is:

$$qs_1 - qd_1 = \left[\left(\frac{\alpha_2}{\beta_2} + \frac{\mu_2}{\sigma_2}\right) + \left(\frac{\alpha_3}{\beta_3} + \frac{\mu_3}{\sigma_3}\right)\right]$$
$$+ \left[\left(\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right)\left(\frac{S_2}{s_2 r_2}\right) + \left(\frac{1}{\beta_3} + \frac{1}{\sigma_3}\right)\left(\frac{S_3}{s_3 r_3}\right)\right]$$
$$- \left[\left(\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right)\left(\frac{1}{s_2 r_2}\right) + \left(\frac{1}{\beta_3} + \frac{1}{\sigma_3}\right)\left(\frac{1}{s_3 r_3}\right)\right] p_1$$

The weights in the harmonic mean of the exchange rates in the constant term differ from the weights in the slope. The consequences of proportional and per-unit tariffs and subsidies will be examined subsequently. When they are absent, S = 0 and s = 1, and the demand relation associated with net exports of country 1 simplifies to:

$$qs_1 - qd_1 = \left[\left(\frac{\alpha_2}{\beta_2} + \frac{\mu_2}{\sigma_2}\right) + \left(\frac{\alpha_3}{\beta_3} + \frac{\mu_3}{\sigma_3}\right)\right]$$
$$- \left[\left(\frac{1}{\beta_2} + \frac{1}{\sigma_2}\right)\left(\frac{1}{r_2}\right) + \left(\frac{1}{\beta_3} + \frac{1}{\sigma_3}\right)\left(\frac{1}{r_3}\right)\right] p_1$$

Substituting the numerical parameters used in the example hides some of the useful structural information, but it highlights the way the exchange rates enter the relation as a weighted harmonic mean of the individual exchange rates.

$$qs_1 - qd_1 = 300 - \left[\frac{160}{r_2} + \frac{130}{r_3}\right] p_1$$

Reconsideration of proportional and per-unit tariffs and subsidies expands the above equation to:

$$qs_1 - qd_1 = 300 + \left[\frac{160\ S_2}{s_2 r_2} + \frac{130\ S_3}{s_3 r_3}\right] - \left[\frac{160}{s_2 r_2} + \frac{130}{s_3 r_3}\right] p_1$$

When per-unit tariffs and subsidies (S) are absent, proportional tariffs and subidies (s) enter the equation exactly as exchange rates do. That is, a 10-percent tariff has exactly the same consequence as a 10-percent appreciation, and a 10-percent subsidy has exactly the same effect as a 10-percent devaluation.

The presence of per-unit tariffs and subsidies affects the constant term. When the per-unit measure is present, the proportional measure affects the constant as well as the slope. The general consequences of S on trade are similar to those of s or r: a per-unit subsidy, a proportional subsidy, or a devaluation increases the demand for exports and increases the elasticity of demand. The demand shift raises prices to farmers in the exporting country and decreases prices to consumers in the importing country. That is, farmers in the exporting country and consumers in the importing country gain from the policy, whereas farmers in the importing country and consumers in the exporting country lose.

Tariffs make the demand for net exports more inelastic, and subsidies make it more elastic. In the simulation, the policy levels required to make a noticeable change were not great. A 10-percent tariff against both countries cut the price elasticity of demand for net exports about in half. It may be that the presence of tariffs, subsidies, transportation costs, and other barriers to trade, which can be interpreted as changes in the coefficients of the equations used here, can explain much of the discrepancy over empirically and theoretically determined export elasticities. Tariffs and subsidies may be selective by commodity, whereas exchange rates are usually selective by country. That is, one can specify a combination of proportional tariffs and subsidies and exchange rates that achieve any desired distribution of commodities by region.

As a further simplification, consider a single exchange rate reflecting prices in country 1 against a weighted average of prices in other countries, such as the Special Drawing Right (SDR). To illustrate, let the two exchange rates be equal ($r = r_1 = r_2$). Leave out tariffs and subsidies. The export demand relation reduces to:

$$qs_1 - qd_1 = 300 - \left[\frac{290}{r}\right] p_1$$

Or, to generalize:

$$\text{Export demand} = \Phi + \theta\,(p_1 \div r)$$

Where Φ and θ are functions of the parameters used in the example. This is the form most likely to be found in existing domestic agricultural models that recognize international trade. The major limitation to using this form of the export demand equation is that the structure underlying Φ and θ is changeable; the data required to identify the structure are not readily available.

The price transmission equations and the net export demand equation discussed here provide clues for correcting specification errors. If the demand for exports were to be estimated for a period during which exchange rates were constant, as they were prior to 1971, then the rates need not be explicit and may be subsumed in the θ coefficient. But with the volatility observed in exchange rates for more than a decade, these rates require explicit attention in models designed to explain and forecast agricultural exports. The review of empirical work suggests that Φ and θ should be considered as functions of other things as well, such as transportation differentials, tariffs and subsidies, price insulation, relative rates of inflation, and the volatility introduced by the interventions and policy reversals of various governments. The review of theory suggests the use of a harmonic mean of exchange rates weighted by the slopes of the relevant demand and supply curves. Price and the exchange rate enter the export demand equation multiplicatively with a shared coefficient (θ) and not additively with separate coefficients. When it is assumed to be additive, empirical estimates of the elasticity of exports with respect to exchange rates may be relatively high (*5*).

Both theoretical and empirical considerations suggest that the depreciation of the U.S. dollar, which accompanied the decrease in prices received by farmers during the past 2 years, and the prospects for further depreciation over the life of the Food Security Act of 1985, could lift export levels of U.S. farm products substantially above those forecast by models that rely on price effects alone. This discussion has pointed to factors to consider when incorporating price transmission relationships into agricultural models. Furthermore, it has shown that export demand depends on more than relative prices and exchange rates.

References

(1) Bredahl, Maury E., and Paul Gallagher. "Comment on Effects of an Exchange Rate Change on Agricultural Trade," *Agricultural Economics Research*, Vol. 29, No. 2, Apr. 1977, pp. 45-48.

(2) Bredahl, Maury E., William H. Meyers, and Keith J. Collins. "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of the Price Transmission Elasticity," *American Journal of Agricultural Economics*, Vol. 61, No. 1, Feb. 1979, pp. 58-63.

(3) Bredahl, Maury E., and Abner W. Womack. "Currency Adjustments under Trade Restrictions," *Agricultural Economics Research*, Vol. 30, No. 1, Jan. 1978, pp. 53-55.

(4) Chambers, Robert G. "Agricultural and Financial Market Interdependence in the Short Run," *American Journal of Agricultural Economics*, Vol. 66, No. 1, Feb. 1984, pp. 12-24.

(5) __________, and Richard E. Just. "A Critique of Exchange Rate Treatment in Agricultural Trade Models," *American Journal of Agricultural Economics*, Vol. 63, No. 1, Feb. 1981, pp. 32-46.

(6) Collins, H. Christine. "Price and Exchange Rate Transmission," *Agricultural Economics Research*, Vol. 32, No. 4, Oct. 1980, pp. 50-55.

(7) Collins, Keith J., William H. Meyers, and Maury E. Bredahl. "Multiple Exchange Rate Changes and U.S. Agricultural Commodity Prices," *American Journal of Agricultural Economics*, Vol. 62, No. 4, Nov. 1980, pp. 656-65.

(8) Coyle, Barry, Robert G. Chambers, and Andrew Schmitz. *Economic Gains From Agricultural Trade: A Review and Bibliography.* BLA-48. U.S. Dept. of Agr., Econ. Res. Serv., July 1986.

(9) Dutton, John, and Thomas Grennes. *Measurement of Effective Exchange Rates Appropriate for Agricultural Trade.* Economics Research Report No. 51. North Carolina State Univ.-Raleigh, Nov. 1985.

(10) Greenshields, Bruce L. *Changes in Exchange Rates: Impact on U.S. Grain and Soybean Exports to Japan.* FAER-364. U.S. Dept. of Agr., Econ. Res. Serv., July 1974.

(11) Jabara, Cathy J. "Cross-Sectional Analysis of Wheat Import Demand among Middle-Income Developing Countries," *Agricultural Economics Research*, Vol. 34, No. 3, July 1982, pp. 34-37.

(12) Johnson, Paul R., Thomas Grennes, and Marie Thursby. "Devaluation, Foreign Exchange Controls and Domestic Wheat Prices," *American Journal of Agricultural Economics*, Vol. 59, No. 4, Nov. 1977, pp. 619-27.

(13) Kost, William E. "Effects of an Exchange Rate Change on Agricultural Trade," *Agricultural Economics Research*, Vol. 28, No. 3, July 1976, pp. 99-106.

(14) Longmire, Jim, and Art Morey. *Strong Dollar Dampens Demand for U.S. Farm Exports*, FAER-193. U.S. Dept. of Agr., Econ. Res. Serv., Dec. 1983.

(15) Meyers, William H. "Exchange Rates in International Commodity Models: The Common Currency Question," *Agricultural Economics Research*, Vol. 31, No. 4, Oct, 1979, pp. 40-43.

(16) __________, Elizabeth J. Gerber, and Maury E. Bredahl. "The Effect of Price-Insulating Policies on Exchange Rate Analysis," *Agricultural Economics Research,* Vol. 32, No.1, Jan. 1980, pp. 25-30.

(17) Orden, David. "The Exchange Rate and Agricultural Prices: A Comment on Some Neglected Income Effects," *American Journal of Agricultural Economics*, Vol. 68, No. 4, Nov. 1986.

(18) Schuh, G. Edward. "The Exchange Rate and U.S. Agriculture," *American Journal of Agricultural Economics,* Vol. 56, No. 1, Feb. 1974, pp. 1-13.

(19) Vellianitis-Fidas, Amalia. "The Impact of Devaluation on U.S. Agricultural Exports," *Agricultural Economics Research*, Vol. 28, No. 3, July 1976, pp. 107-16.

wrong title for AJAE ref

Quarterly Livestock Sector Adjustments to Changes in Feed Grain Prices

By Paul C. Westcott, Richard P. Stillman, and Keith J. Collins

Abstract

A quarterly econometric model for U.S. agriculture is used to illustrate shortrun and longrun adjustments in major livestock subsectors resulting from changes in feed grain prices. Adjustments in the different livestock subsectors differ sharply in both speed and magnitude because of underlying biological and economic constraints, feed-use efficiencies, and industry structures. All livestock producers benefit from lower feed grain prices. Cattle feeders, hog producers, and dairy producers appear to benefit most in the long run, whereas poultry producers and cow-calf enterprises benefit least. Consumers also benefit from reduced feed grain prices because retail prices for meats are generally lower after an initial period of somewhat higher meat prices as current production is reduced to expand cattle and hog breeding herds.

Keywords

Feed grains, livestock, quarterly model, cross-commodity linkages, biological constraints, net returns, model simulations, impact analysis

This article examines quarterly adjustments in the livestock sector resulting from reductions in feed grain prices as could occur under the Food Security Act of 1985. Even small policy changes for feed grains can have large effects on the livestock sector because of the importance of feed grains in the livestock production process. Total U.S. farm expenditures for feed were about $20 billion in 1984, almost 15 percent of all farm production expenses (*6*).[1] Feed expenditures exceeded spending on inputs such as seed, fertilizers, and fuel, and nearly equaled the combined interest charges on short-term and real estate debt.

Feed grains account for roughly half the total value of grains, oilseed meals, and hay used in animal feeding. In turn, domestic animal feeding is the largest single use of feed grains, accounting for about 60 percent of annual disappearance. This interdependency means that changes in feed grain policies that alter feed grain prices can have substantial effects on the profitability of livestock production. The effects are direct, through lower feed grain costs, and indirect, through induced changes in costs of complementary and substitute feeds. In addition, cost-of-production changes cause adjustments in livestock production, which further alter profitability through price changes in livestock and livestock products.

As livestock production operations have become larger and more specialized, leading to fewer mixed enterprises, feed grain/livestock interdependencies have become more important. Livestock producers, therefore, are now more vulnerable to swings in feed prices and, consequently, feed grain policies are more important for livestock producers (*1, 3*). Such cross-commodity effects are often given secondary importance in the formulation and evaluation of crop policies. The main goal of crop policies is usually to enhance the income of crop producers. Furthermore, in the debate leading to the Food Security Act of 1985, the need for lower loan rates was almost completely attributed to the loss of competitiveness in export markets for crops, the need to

---

Westcott and Stillman are agricultural economists with the National Economics Division, ERS; Collins is an agricultural economist with the Economic Analysis Staff, U.S. Department of Agriculture.

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

regain market share, and the need to reduce program outlays to lower the budget deficit.

In an article discussing the effects of Federal grain programs on the livestock sector, Todd surveyed a number of econometric models and calculated the longrun effects on livestock production, prices, and gross income (*10*). An increase in feed grain prices will generally cause production in the livestock sector to fall in the long run, with prices and gross income rising. Todd points out, however, that most of the estimated increases in gross income are too small to cover the higher feed grain costs, so producer returns net of feed costs are lower in the long run.

In this article, we use a quarterly econometric model to illustrate quarterly adjustment patterns in major livestock subsectors that result from a reduction in feed grain prices. This allows us to examine, not only the longrun impacts on livestock production, prices, income, and net returns, as Todd did, but also, with the quarterly framework, the dynamic time paths of adjustments to compare shorter run impacts across the different livestock subsectors. Of particular interest are the adjustments of production and prices and the comparison of gross receipts and net returns of livestock producers with each other and across time.

The Model

The analysis uses a quarterly econometric model of the U.S. agricultural sector, including subsector models for corn, wheat, soybeans, cattle, hogs, poultry, and dairy (*13, 14*).

An important feature of the model is its explicit linkages between and among the crop and livestock subsectors, thereby allowing examination of cross-commodity effects of alternative scenarios. Two types of cross-commodity linkages are of particular importance for our application. First are the linkages between feed grains and livestock subsectors. These linkages primarily occur in equations for decision variables affecting livestock production as feed grain prices are used to represent major livestock production costs. The second important types of linkages are those among the various livestock subsectors. These linkages occur primarily in the pricing equations where the price of any particular meat is generally affected by production of competing meats.

The livestock subsectors also include lags that reflect biological constraints on the different production processes and on the addition of animals to the breeding stocks (figs. 1-5). Cattle and dairy producers face the longest biological constraints.

Because we are primarily interested here in livestock sector adjustments, we now present a summary of the livestock subsectors in the model.[2]

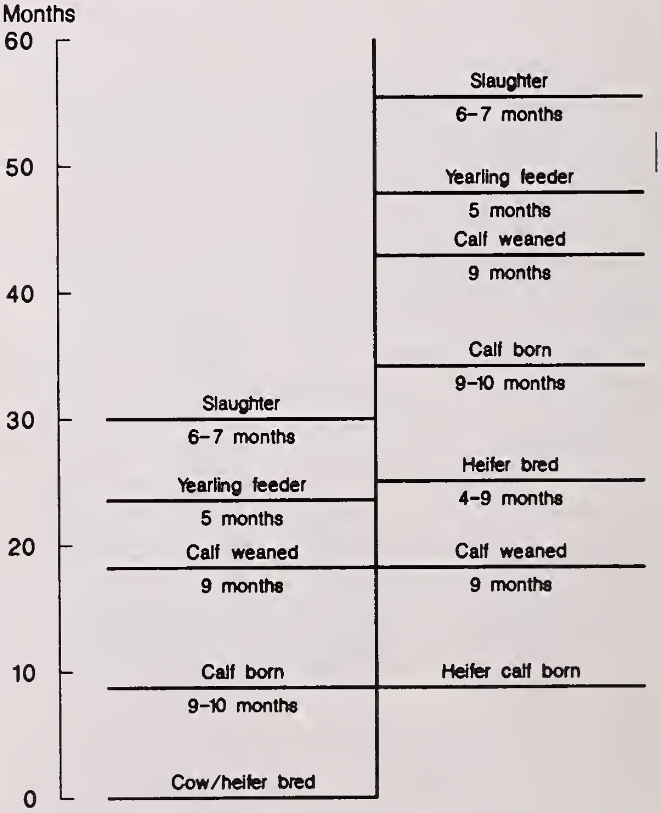
Cattle

In the cattle sector, cow-calf operations are represented by eight annual cattle inventory equations and two quarterly breeding herd liquidation equations. Because the cow inventory represents the capital stock from which cattle production is drawn, these equations set production constraints for the rest of the cattle subsector.

The three most important categories in representing cow-calf operations are additions to the breeding herd, breeding herd liquidations, and the

Figure 1

Cattle Sector Biological Lags



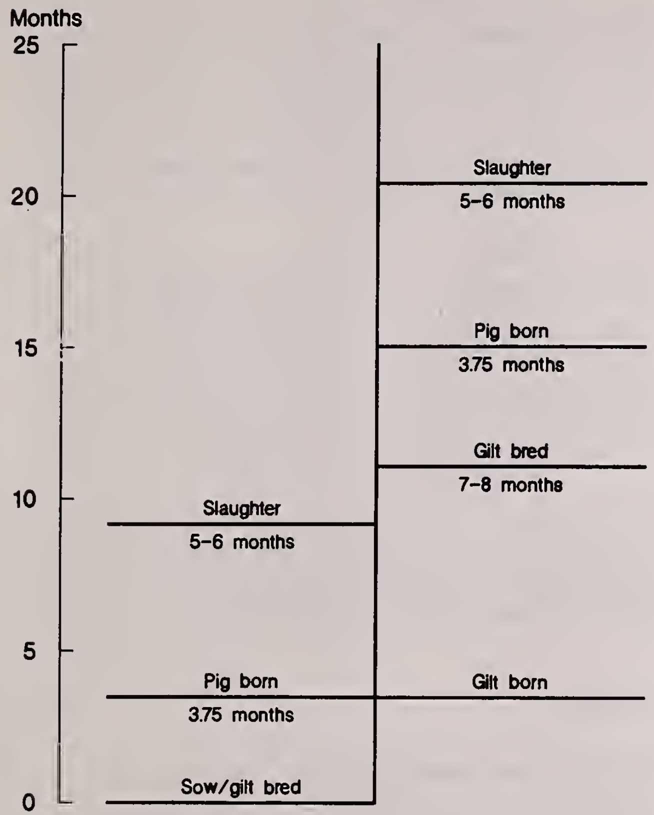
Based on (*2, 7*).

---

[2] Readers interested in a discussion of the crop subsectors, a more detailed discussion of the livestock subsectors, a presentation of the model's individual equations, or model validation statistics are referred to (*13*) and (*14*).

Figure 2

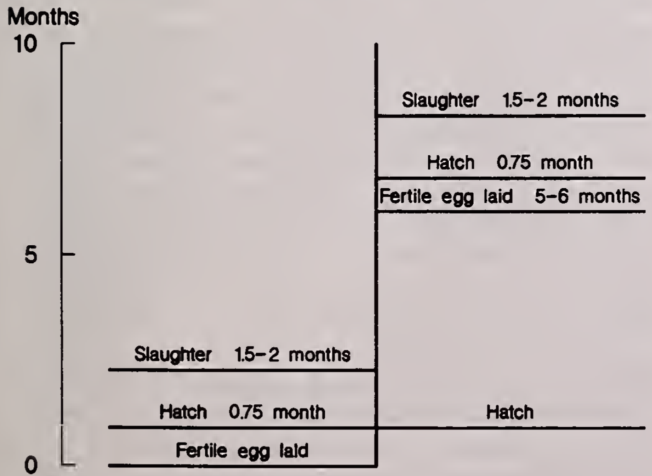
Hog Sector Biological Lags



Based on (*4, 11*).

Figure 3

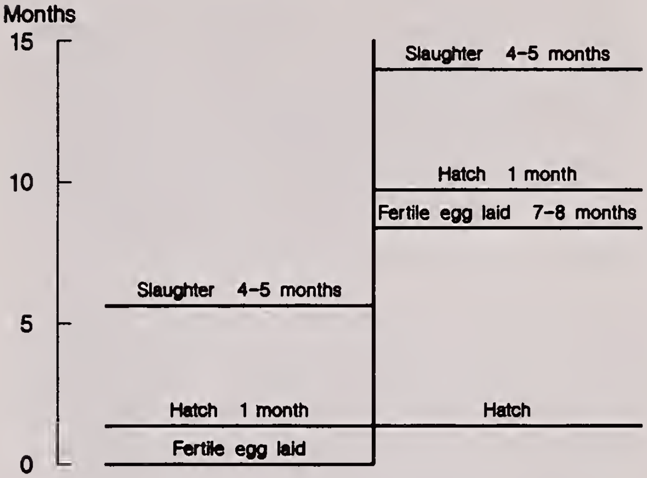
Broiler Sector Biological Lags



Based on (*5*).

Figure 4

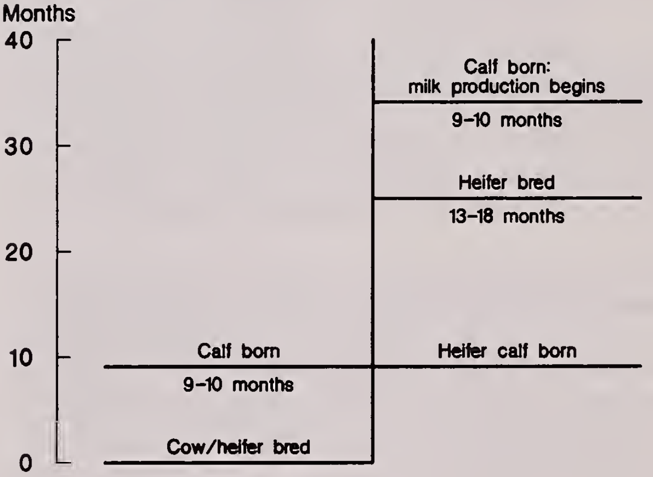
Turkey Sector Biological Lags



Based on (*9*).

Figure 5

Dairy Sector Biological Lags



Based on (*7*).

calf crop. Additions to the breeding herd and the calf crop are functions of deflated feeder steer prices, representing expected returns of producing feeders and deflated hay prices as a proxy for grazing conditions. Breeding herd liquidations are inversely related to a distributed lag of feeder steer prices, again to represent expected returns of producing feeders.

The equation for net placements of cattle into feedlots provides the major linkages between feed grain prices and the cattle sector as well as the linkages between cow-calf operations and cattle feeders. Net placements are a function of expected returns of feeding relative to feed costs, represented by a ratio of a distributed lag of fed-steer prices to lagged corn prices, and a distributed lag of the cost of feeder cattle. Additionally, net feedlot placements are constrained by the size of recent calf crops. Net feedlot placements are used to derive fed-cattle marketings and fed-steer and heifer slaughter.

Nonfed steer and heifer slaughter is also a function of fed-steer prices and corn prices, although these factors have the opposite effect here than they do in the feedlot placement decision. The more attractive cattle feeding is, the smaller is nonfed slaughter. Furthermore, similar to the net placements equation, nonfed slaughter is constrained by the size of recent calf crops.

Combining breeding herd liquidations with both fed and nonfed steer and heifer slaughter and then multiplying by averaged dressed weights gives commercial beef production. One adds beginning stocks, imports, and farm production of beef to commercial production to derive total beef supplies.

Cold storage beef stocks are estimated as a function of beginning stocks and imports. Exports, shipments, and military use of beef are exogenous. The model derives beef consumption in an identity by subtracting ending cold storage stocks, exports, shipments, and military use from total beef supplies.

The price for fed steers is a function of fed and nonfed steer and heifer slaughter and disposable personal income. The price for feeder steers is then related to fed-steer prices to represent the demand for feeders, the previous year's calf crop to represent potential feeder supplies, and lagged corn prices to represent expected feeding costs.

Hogs

In the hog subsector, the most important equation is for sows farrowing. Sows farrowing is a function of expected returns to hog production represented by a distributed lag of a seven-market hog price. This equation also includes a one-quarter lag of prices for corn, the major hog feed, to represent expected costs of production. The model multiplies the number of sows farrowing by an exogenously determined number of pigs saved per litter to derive the pig crop as an identity. Barrow and gilt slaughter then draws on the pig crops in the two previous quarters, representing the 5- to 6-month farrow-to-finish production process.

Sow slaughter and boar slaughter represent breeding herd liquidation decisions. They depend on expected returns and costs, represented by lagged hog prices and corn prices. Total hog slaughter is the sum of barrow and gilt slaughter, sow slaughter, and boar slaughter. A series of pork supply identities give pork production and total pork supplies.

The equation for ending cold storage pork stocks is a function of beginning stocks and production. Exports, shipments, and military use of pork are exogenous as for beef, and the model derives pork consumption in an identity by subtracting ending cold storage stocks, exports, shipments, and military use from total pork supplies.

The average hog price for seven major markets is a function of pork production, representing supplies; beef production, representing competing meat supplies; and disposable personal income.

Poultry

In the poultry subsector, broiler pullets placed in hatchery supply flocks represent additions to the capital stock from which slaughter broilers are drawn. Expected feeding costs are represented by a two-quarter lag of a feed cost variable, derived by using a 70-percent corn and a 30-percent soybean meal feed ration. Expected returns are represented by a two-quarter lag of broiler prices.

Broilers hatched draw from the hatchery supply flock, represented by a weighted moving sum of pullets placed two to four quarters earlier. The equation for broilers hatched also includes one-quarter lags of broiler prices and feed prices to represent expected returns and expected production costs, respectively. Broiler production is related to the one-quarter lag of broiler hatch to reflect the time needed to bring broilers to market weight. As before, expected returns and costs are represented by lagged prices for broilers and feed. The model derives total chicken supplies by adding beginning cold storage stocks to production.

The equation for ending chicken stocks in cold storage is a function of beginning stocks and broiler production. Similar to beef and pork, the model derives chicken consumption in an identity, subtracting ending cold storage stocks and exogenously determined exports, shipments, and military use from chicken supplies.

The 12-city broiler price is a function of broiler production, representing supplies; beef and pork production, representing competing meat supplies; and disposable personal income.

Turkey production is estimated directly without any explicit link to a supporting set of breeding inventory equations. Turkey production is related to two-quarter lags of turkey prices and corn prices to reflect expected returns and feeding costs. The model derives total turkey supplies by adding beginning cold storage stocks to production.

Ending cold storage stocks of turkey are a function of beginning stocks and turkey production. As in the other meat subsectors, exports, shipments, and military use of turkey are exogenous, and the model derives turkey consumption in an identity by subtracting ending cold storage stocks, exports, shipments, and military use from supplies.

A price equation for turkeys is a function of the sum of beef, pork, and broiler production, representing competing meat supplies, and disposable personal income.

Dairy

In the dairy subsector, the milk cow inventory equation is related to lagged effective milk prices, lagged feed prices (83-percent corn, 17-percent soybean meal), and cattle prices to represent expected returns, production costs for the major dairy feeds, and profitability of competing beef enterprises, respectively. An equation for production per cow is estimated as a function of expected returns, represented by lagged effective milk prices, and production costs, represented by lagged soybean meal prices.

The model derives milk production in an identity by multiplying the milk cow inventory by production per cow. Milk use on farms, commercial dairy stocks, and dairy imports are exogenously determined. Marketings are equal to production minus milk use on farms. Total milk supplies are equal to marketings, beginning commercial dairy stocks, and dairy imports.

Commercial use is the major demand for milk. It is estimated as a function of milk prices to represent factor costs and disposable personal income to represent final product demand.

Net Government removals of milk represent the role of the Government in the dairy sector. This equation serves as the market-clearing equation in the dairy subsector. It sets net Government removals of milk equal to total milk supplies less commercial milk use and ending commercial stocks.

The farm-level milk price is a function of the support price, to reflect the role of the Government; aggregate production, to represent supplies; and commercial milk use, to represent non-Governmental demand factors. An effective milk price is calculated that differs from the farm-level milk price by the level of milk price deductions that producers have been assessed.

Gross Receipts, Net Returns, and Retail Prices

Two additional blocks are appended to the commodity subsectors of the quarterly agriculture model for use in this analysis. First, various indicators of livestock producers' costs and returns are derived (*8*). Estimates of gross receipts and returns net of feed costs for producers of the different types of livestock are provided.

Second, a model for retail prices (*12*) is used to compare adjustments in consumer prices for beef, pork, poultry, and dairy products. This model uses a modified stage of processing approach where the retail price of any product is represented as a function of prices for inputs used in its production, including prices of raw materials and costs of marketing, as well as retail prices for close substitutes or complements. In particular, the retail price equations for beef, pork, and poultry are simultaneous.

The Policy Scenarios

The most significant departure from recent policies in the commodity titles of the Food Security Act of 1985 is the provision for sharply lower loan rates for crops. The changes providing for lower feed grain loan rates include: (1) basing the computed loan rate on a percentage of past market prices, with a maximum annual decline limited to 5 percent, (2) authority to lower loan rates up to an additional 20 percent by use of the so-called Findley Amendment, and (3) authority to allow loan repayment at levels below the loan rate determined for the crop. Moreover, application of the Gramm-Rudman-Hollings balanced budget act has lowered and may continue to lower effective loan rates and market prices.

Here we examine the effects on the livestock sector of lower feed grain prices that could result from implementing lower feed grain loan rates under the provisions of the Food Security Act of 1985. Two dynamic simulations of the quarterly agriculture sector model discussed in the previous section are performed over a 17-quarter period from the October-December quarter of 1986 through the end of calendar year 1990, with different policy assumptions used in each. In the base scenario, we assumed that regular nonrecourse and farmer-owned reserve loan rates for feed grains would continue at their 1985/86 levels. In the alternative scenario, we assumed that loan rates for feed grains would be lowered by about 25 percent from 1985/86 levels beginning in the 1986/87 crop year and extending through the remainder of the simulation. For example, we set the loan rate for corn at $2.55 per bushel in the base scenario and reduced it to $1.92 per bushel in the alternative scenario.

In both simulations, we set prices for corn and other feed grains in the model exogenously equal to their loan rate on a season-average basis, with typical seasonal patterns assumed through the marketing year. For corn, again, we set prices in the base scenario simulation at $2.45 per bushel in each harvest quarter and at $2.55, $2.65, and $2.55 per bushel in the subsequent quarters of each crop year, whereas we set corn prices in the alternative scenario simulation at $1.82 per bushel in each harvest quarter and at $1.92, $2.02, and $1.92 per bushel in the following quarters of each crop year. We also reduced hay prices by about 25 percent in the alternative scenario. Policy assumptions regarding other subsectors were held the same in both scenarios.[3] Other subsectors were, however, left endogenous in the simulations, allowing both direct and indirect effects on livestock to occur. Endogenously determined adjustments in soybean meal prices, for example, affected some livestock sector responses.

We then determined livestock sector adjustments by comparing the two model solutions. These comparisons can be used to address a number of questions concerning crop policy changes on livestock. For example, what classes of livestock initially benefit most from lower feed grain prices? As adjustments occur, how do relative gross incomes and net returns among livestock classes change? How long does it take before the initial increases in net returns are reduced by the livestock production responses? How long is it before benefits to meat consumers begin? The next section discusses these issues.

Results

Tables 1-4 summarize the major impacts in the livestock sector resulting from an approximate 25-percent decline in feed grain loan rates and market prices from 1985/86 levels. The tables show percentage changes in each selected variable from the base scenario solution.

Cattle

Table 1 shows selected impacts in the cattle sector. Lower feed prices, particularly for corn, provide economic incentives for increased cattle feeding. Increased cattle feeding raises the demand for feeder cattle, initially pushing feeder steer prices higher. Higher receipts minus feed costs for cow-calf operators trigger an increase in the breeding herd through reduced cow slaughter and the addition of more heifers. Consequently, the calf crops are larger in the alternative scenario. Cattle placed in feedlots, cattle on feed, and fed-cattle marketings are all higher in the alternative scenario, resulting in higher fed steer and heifer slaughter. Nonfed slaughter, however, is sharply lower as more cattle are placed in feedlots and added to the breeding herd. As a result, total steer and heifer slaughter is initially reduced. Then, beginning in the sixth quarter, higher fed slaughter offsets reduced nonfed slaughter, resulting in increased total steer and heifer slaughter. Fed-steer prices are higher for about a year, during the period that total slaughter is lower. Fed steer prices are subsequently reduced. Consumers face higher retail beef prices for a little more than a year before the effects of the increased total meat production push retail prices below the base scenario levels as well. Total revenues and returns net of feed costs for cattle feeders are higher throughout the simulation period, with the differences from the base scenario narrowing as fed slaughter increases. With lower fed-steer prices after the first year, feeder steer prices are bid down, reducing total revenues for cow-calf operators after the second simulation year. Net returns for cow-calf operators remain higher, however, because of reductions in costs of feed grains, hay, and soybean meal. Consequently, although cow slaughter is generally higher in the latter years of the simulation, largely reflecting the normal culling of a larger herd, a more-than-offsetting number of heifers are added, so the cow inventory remains larger than in the base scenario.

Hogs

Table 2 shows selected impacts in the hog sector. Total revenues minus feed costs rise sharply at

---

[3] For example, we assumed a moderate dairy herd buyout in both scenarios. Furthermore, the milk price support was exogenously set in both scenarios at $11.60 per hundredweight (cwt) in the October-December quarter of 1986, $11.35 per cwt for the first three quarters of 1987, and $11.10 per cwt thereafter.

Table 1—Selected cattle sector impacts of a 25-percent reduction in feed grain prices: Simulated changes from base scenario, 1986-IV through 1990

Year and quarter	Cow slaughter	Heifers entering the cow herd (annual)	Calf crop (annual)	Feeder steer price	Fed steer price	Beef and veal CPI
			Percent change			
1986-IV	0			0	0	0
1987-I	.6	4.2	3.1	8.7	3.5	2.2
1987-II	−2.3			9.1	3.8	3.8
1987-III	−4.1			8.9	3.9	4.0
1987-IV	−4.5			7.1	2.6	3.6
1988-I	−3.7	5.6	4.7	−.8	−3.1	0
1988-II	−.4			−.3	−2.5	−2.1
1988-III	1.7			1.2	−1.2	−.9
1988-IV	1.9			.1	−2.2	−.2
1989-I	3.6	6.0	4.4	−7.4	−8.0	−3.2
1989-II	6.4			−5.7	−6.4	−4.3
1989-III	7.8			−3.4	−4.4	−2.5
1989-IV	6.9			−3.0	−4.2	−1.6
1990-I	7.3	5.1	4.4	−7.6	−8.3	−3.5
1990-II	8.3			−6.3	−6.9	−4.5
1990-III	8.7			−3.6	−4.6	−3.1
1990-IV	7.3			−3.1	−4.3	−2.3

		Steer and heifer slaughter			Total revenues		Total revenues minus feed costs	
	Feedlot placements	Fed	Nonfed	Total	Cow-calf	Feeding	Cow-calf	Feeding
				Percent change				
1986-IV	0	0	0	0	0	0	10.2	6.9
1987-I	4.5	1.0	−77.4	−2.4	9.3	4.6	24.6	12.5
1987-II	5.9	2.1	−86.2	−2.4	9.6	6.0	25.0	13.8
1987-III	7.1	3.2	−75.7	−2.2	9.4	7.3	22.6	14.8
1987-IV	12.0	5.8	−63.3	−.8	7.7	8.5	19.7	15.8
1988-I	10.8	7.0	−87.6	4.2	.9	3.7	10.4	9.3
1988-II	7.7	7.0	−88.9	3.9	1.4	4.3	11.1	9.9
1988-III	9.7	7.5	−91.7	2.8	2.9	6.2	12.2	12.2
1988-IV	13.5	9.4	−64.2	4.1	1.8	7.0	10.3	12.7
1989-I	11.9	10.1	−50.0	9.6	−4.8	1.2	1.5	5.3
1989-II	7.3	9.2	−71.9	8.1	−3.1	2.2	3.8	6.5
1989-III	9.5	9.1	−84.5	6.1	−.7	4.3	6.4	9.2
1989-IV	11.5	10.0	−52.0	6.3	−.4	5.3	6.7	10.3
1990-I	11.3	10.4	−50.0	10.0	−5.1	1.3	1.0	5.2
1990-II	6.2	9.2	−51.3	8.7	−3.7	1.6	2.8	5.6
1990-III	8.7	8.9	−84.9	6.3	−.9	3.9	6.1	8.6
1990-IV	11.2	9.8	−50.4	6.3	−.4	5.0	6.6	9.9

Note: Heifers entering the cow herd and the calf crop are annual variables in the model. Percentage changes shown for these variables are, therefore, annual impacts.

Blanks indicate not applicable.

Table 2—Selected hog sector impacts of a 25-percent reduction in feed grain prices: Simulated changes from base scenario, 1986-IV through 1990

Year and quarter	Sow slaughter	Sow farrowings	Barrow and gilt slaughter	Hog Slaughter	Hog price	Total revenues	Total revenues minus feed costs	Pork CPI
				Percent change				
1986-IV	−7.0	0	0	−0.4	0.7	0.3	16.4	0.2
1987-I	−9.2	3.2	0	−.4	2.7	2.2	27.5	1.4
1987-II	−5.9	5.0	1.1	.7	.1	.9	31.0	1.6
1987-III	−2.6	6.9	4.0	3.6	−6.0	−2.7	10.5	−.4
1987-IV	.9	6.3	5.6	5.3	−10.4	−5.7	−.4	−3.1
1988-I	4.6	6.7	6.5	6.3	−17.4	−12.2	−14.9	−6.7
1988-II	8.4	4.3	6.0	6.1	−17.7	−12.6	−16.3	−8.8
1988-III	8.0	2.4	5.7	5.9	−14.5	−9.5	−7.0	−7.7
1988-IV	5.3	−.2	3.6	3.7	−9.8	−6.5	1.0	−5.4
1989-I	2.1	−.5	1.3	1.4	−9.8	−8.5	2.3	−4.9
1989-II	.2	−1.3	−.3	−.2	−5.4	−5.6	16.5	−4.1
1989-III	−2.9	−1.7	−.8	−.9	−2.4	−3.3	21.9	−2.0
1989-IV	−4.7	−1.7	−1.4	−1.6	−.5	−2.1	17.9	−.6
1990-I	−8.2	.5	−1.7	−1.9	−2.7	−4.6	19.7	−1.1
1990-II	−5.1	1.1	−.8	−1.0	−3.9	−4.9	23.1	−2.2
1990-III	−3.5	1.6	.8	.5	−6.1	−5.6	16.1	−2.6
1990-IV	−2.0	1.3	1.3	1.1	−6.4	−5.4	8.4	−2.9

Table 3—Selected poultry sector impacts of a 25-percent reduction in feed grain prices: Simulated changes from base scenario, 1986-IV through 1990

Year and quarter	Broiler production	Broiler price	Broiler revenues	Broiler revenues minus feed costs	Turkey production	Turkey price	Turkey revenues	Turkey revenues minus feed costs	Poultry CPI
					Percent change				
1986-IV	0	0.3	0.3	12.0	0	0.2	0.2	9.0	0.1
1987-I	.3	1.7	2.0	15.1	0	1.7	1.7	11.5	.9
1987-II	1.5	−1.4	0	14.1	3.0	.6	3.6	14.7	.5
1987-III	1.4	−3.3	−1.9	8.6	2.6	−1.0	1.6	10.7	−.4
1987-IV	.9	−4.6	−3.7	4.8	2.4	−2.5	−.2	6.8	−1.5
1988-I	1.1	−9.7	−8.7	−2.9	3.4	−6.7	−3.6	2.4	−4.2
1988-II	.9	−10.3	−9.5	−2.4	2.1	−6.8	−4.9	2.1	−5.7
1988-III	.7	−7.6	−7.0	1.2	.6	−5.3	−4.7	2.5	−4.7
1988-IV	.8	−6.8	−6.1	1.7	.7	−4.5	−3.8	2.6	−3.6
1989-I	1.1	−10.1	−9.1	−3.0	1.7	−7.3	−5.8	.1	−4.4
1989-II	.8	−8.5	−7.7	1.7	1.3	−5.9	−4.6	3.2	−4.2
1989-III	.7	−5.6	−5.0	5.5	.4	−3.9	−3.6	4.6	−2.8
1989-IV	1.2	−5.5	−4.3	4.8	.9	−3.3	−2.5	4.6	−2.1
1990-I	1.5	−8.9	−7.5	−.4	2.1	−6.0	−4.0	2.6	−3.2
1990-II	1.1	−9.1	−8.1	1.0	1.7	−5.9	−4.4	3.4	−3.9
1990-III	.9	−7.4	−6.6	2.9	.7	−5.0	−4.3	3.4	−3.6
1990-IV	1.2	−7.6	−6.5	1.4	.8	−4.8	−4.0	2.6	−3.5

Table 4—Selected dairy sector impacts of a 25-percent reduction in feed grain prices: Simulated changes from base scenario, 1986-IV through 1990

Year and quarter	Milk cow inventory	Milk production	Commercial milk use	Milk price	Net Government removals	Total revenues	Total revenues minus feed costs	Dairy CPI
				Percent change				
1986-IV	0	0	0	0	−0.1	0	8.9	0
1987-I	0	0	0	0	.2	.6	10.2	0
1987-II	.1	0	0	0	.2	.6	10.5	0
1987-III	.1	0	0	0	.9	.6	10.0	0
1987-IV	.1	0	0	0	2.4	.5	9.4	0
1988-I	.2	.1	0	−.1	1.2	−.2	9.2	0
1988-II	.3	.3	.01	−.2	3.2	−.1	9.7	−.1
1988-III	.3	.3	.01	−.3	16.3	.1	9.3	−.1
1988-IV	.4	.4	.01	−.3	15.5	0	8.6	−.2
1989-I	.5	.5	.01	−.4	5.7	−.7	8.4	−.2
1989-II	.6	.7	.02	−.6	11.2	−.5	8.9	−.3
1989-III	.7	.8	.02	−.7	16.7	−.2	8.6	−.3
1989-IV	.8	.8	.02	−.6	16.4	−.1	8.2	−.3
1990-I	.9	.9	.02	−.8	12.0	−.6	8.3	−.4
1990-II	1.0	1.1	.02	−1.0	23.6	−.6	8.6	−.5
1990-III	1.1	1.1	.02	−1.0	17.7	−.2	8.5	−.5
1990-IV	1.2	1.2	.02	−.9	17.8	0	8.2	−.5

first. As in the cattle sector, this increase diminishes breeding herd liquidations in the first year, with sow slaughter and boar slaughter lower for the first four quarters. Larger breeding herds then lead to increased sow farrowings, pig crops, and barrow and gilt slaughter. As a result, total hog slaughter is initially lower, but then rises above the base scenario levels. Combined with other livestock sector supply responses, these adjustments result in higher hog prices for the first three quarters, followed by lower prices thereafter. Similarly, consumer prices for pork are initially higher, but then fall below base levels after the third quarter. After the first year, total revenues minus feed costs fall for four quarters from the base scenario levels before again rising above the base starting in late 1988. Consequently, breeding herd liquidations are higher for over a year before declining again after net returns rise. The resulting cyclical adjustment patterns are shorter and more pronounced than in the cattle sector, reflecting the shorter biological lags in hog production, the larger portion of production costs accounted for by feed grains, and the greater importance of mixed enterprise farms in the hog industry. Having a mixed corn/hog operation provides more producer options as corn can be marketed through hog feeding or sold directly.

Poultry

Broiler and turkey production both increase relative to the base scenario, although increases are generally smaller than in the cattle and hog sectors (table 3). With relatively short biological constraints, poultry production increases are largest in the first three to six quarters before cattle and hog sector adjustments lead to higher red meat production. Poultry prices are higher in the short run, which reflects initially reduced total supplies of red meats and poultry. Poultry prices then decline, however, as poultry and red meat production increase. The largest poultry price declines, however, occur after those periods when poultry production adjustments are largest, reflecting the increased production of competing red meats. Consumer prices for poultry are lower after the third quarter, with the largest declines also occurring when red meat production is higher. Although total revenues are lower after the initial three to four quarters, producer returns net of feed costs remain above the base scenario throughout most of the simulation interval, providing the economic incentive for continued higher production.

Dairy

Impacts on production of dairy products, commercial use, and prices are relatively small (table 4). Milk cow inventories rise in response to higher net returns, although biological constraints limit the expansion. Production per cow falls initially, reflecting the implicit retention at the margin of cows that would have otherwise been culled. Production per cow then rises, reflecting lower feeding costs.

Figure 6

Impacts of Lower Feed Grain Prices on Gross Revenues: Cow Calf, Fed Cattle, and Hogs

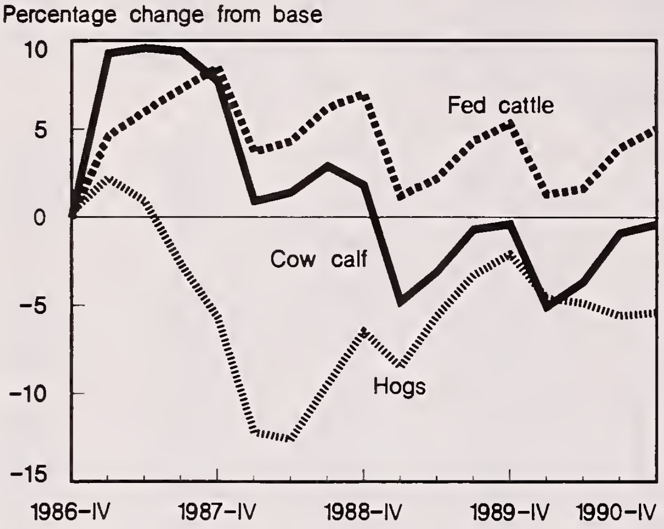
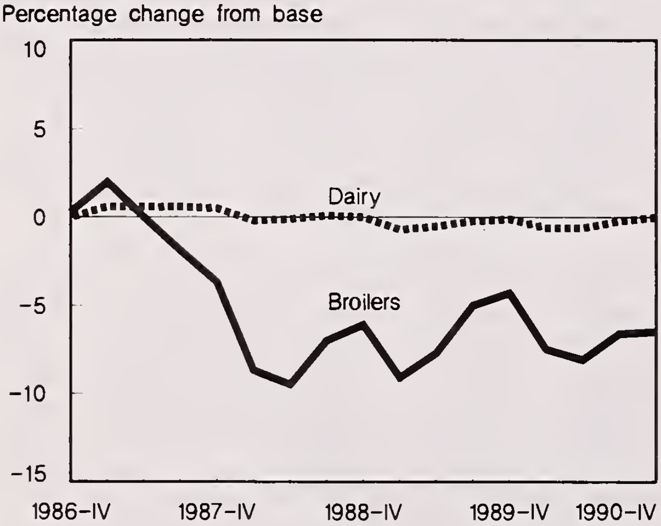


Figure 7

Impacts of Lower Feed Grain Prices on Gross Revenues: Broilers and Dairy



The resulting production gains, however, are minimal as are changes in commercial use and prices. Nonetheless, increases in production exceed those in use, resulting in higher net Government removals of dairy products. Without an accompanying revision in dairy policy, reduced market prices for feed grains would increase Government costs of the dairy programs.

Gross Revenues and Net Returns

We can measure the differential impact of the change in feed grain prices on producers of the various types of livestock products by comparing changes in their gross revenues and returns net of feed costs. Gross receipts for cattle feeders are higher throughout the simulation period as their production increases offset their price declines (figs. 6 and 7).[4] Gross receipts for cow-calf enterprises are initially higher as well, but then fall below base scenario levels after about 2 years. Gross revenues for other livestock producers are generally lower after three to five quarters with reduced feed grain prices.

As Todd (*10*) points out, however, a more appropriate measure of producer well-being is total revenues minus feed costs (net returns).[5] All livestock producers appear to benefit from lower feed grain prices because net returns are generally all higher than in the base scenario (figs. 8 and 9). The initial rise in net returns is led by hog producers, cow-calf operations, and poultry producers. Cattle feeders, hog producers, and dairy producers appear to benefit most in the longer run, although net returns for hog producers display a pronounced cyclical pattern with lower net returns in four quarters. Poultry producers and cow-calf enterprises appear to benefit least in the longer run. Even so, except for broiler returns in 4 of the 17 quarters, net returns for poultry producers and cow-calf enterprises are still increased with lower feed grain prices.

Consumer Prices

Consumer prices for all meats ultimately are lower with reduced prices for feed grains (fig. 10). In the short run, however, retail prices for beef, pork, and poultry are higher as red meat production is reduced while breeding herds are expanded. The length of time that retail beef and pork prices are higher reflects the biological constraints involved; pork prices are higher in the initial impact and two subsequent quarters, and beef prices are higher in the initial impact and four subsequent quarters. Poultry prices are higher in the first impact and two subsequent quarters, although biological constraints for poultry production are shorter, because

---

[4] Impacts on gross revenues and net returns for turkey producers have similar patterns, although not identical magnitudes, to those for broiler producers and, consequently, are not included in the graphs.

[5] This measure also seems to be more consistent with the implied economic incentives underlying the production responses discussed earlier.

Figure 8

Impacts of Lower Feed Grain Prices on Net Returns: Cow Calf, Fed Cattle, and Hogs

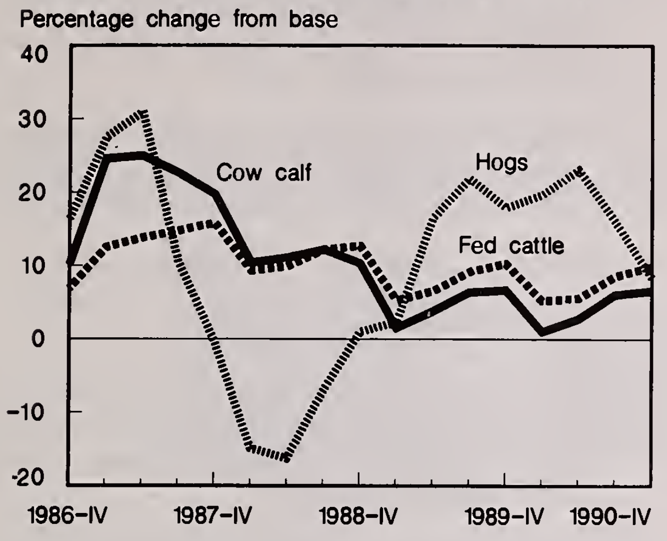


Figure 10

Impacts of Lower Feed Grain Prices on Consumer Prices

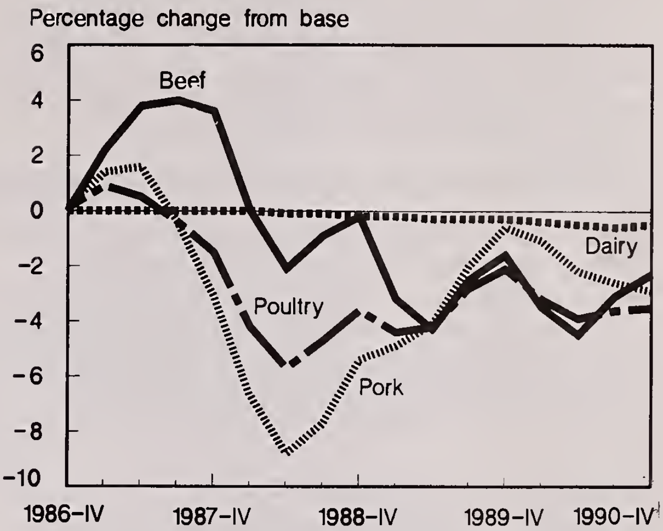
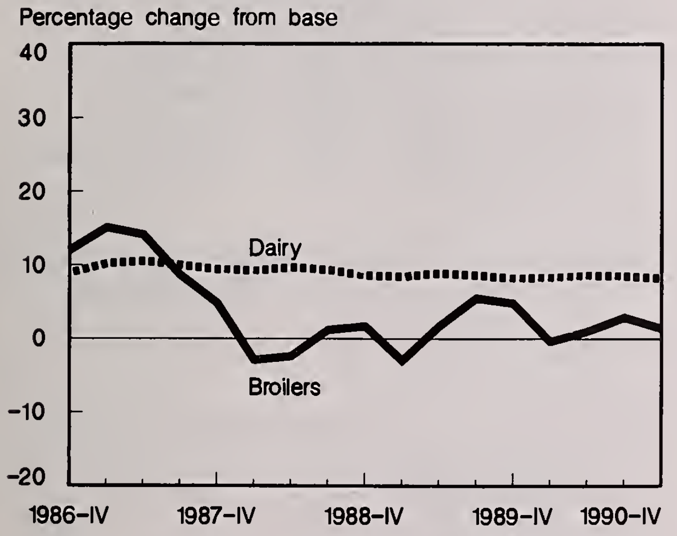


Figure 9

Impacts of Lower Feed Grain Prices on Net Returns: Broilers and Dairy



reduced supplies of red meats offset poultry production increases.

Conclusions

Adjustments in the different livestock subsectors resulting from a decline in feed grain prices differ sharply in both speed and magnitude because of underlying biological and economic constraints, feed-use efficiencies, and industry structures. Thus, the timing and magnitude of benefits also differ for various livestock producers. Results of the model simulations conducted here suggest that all livestock producers benefit from lower feed grain prices. Hog producers, cow-calf operations, and poultry producers benefit most in the short run. In the longer run, cattle feeders, hog producers, and dairy producers appear to benefit most, whereas poultry producers and cow-calf enterprises apparently benefit least.

Cattle feeders have a consistently large increase in returns net of feed costs over the simulation period. Biological lags in increasing the supply of feeder cattle, however, restrict the speed and magnitude of feedlot expansion in the short run. Cow-calf enterprises have their largest increases in net returns in the first two simulation years when the increased demand for feeders exceeds the biologically constrained supply response. In subsequent periods, cow-calf operators appear to benefit relatively less as increases in their net returns are smaller.

The speed and magnitude of adjustments in the hog sector are less constrained by biological factors than in the cattle sector. In addition, the relative importance of mixed-enterprise farms in the hog industry facilitates the marketing of corn through hog feeding as an alternative to selling corn directly. As a consequence, the hog sector overresponds to the lower feed grain prices, causing pronounced cyclical adjustments.

The largest poultry production adjustments are in the short run because poultry is least constrained by biological lags. Over the longer run, poultry production adjustments are the smallest among meat producers. However, reductions in producer prices are larger in the longer run, reflecting increased production of competing meats. As a result, poultry producers appear to benefit least in the longer run as the impacts on their net returns are the smallest.

Dairy producers benefit from the reduction in feed grain prices. Their costs are reduced, but production, consumption, and prices of milk change little, reflecting biological constraints to herd expansion and the role of price supports in the sector. Government removals of dairy products are higher for almost the entire simulation period.

Consumers also benefit. Retail prices for meats are generally lower following an initial period of somewhat higher meat prices as production is first reduced to increase cattle and hog breeding herds.

References

(1) Breimyer, Harold F., and V. James Rhodes. "Livestock Aspects of Feed Grain Policy," *American Journal of Agricultural Economics,* Vol. 57, No. 5, Dec. 1975, pp. 945-48.

(2) Gilliam, Henry C., Jr. *The U.S. Beef Cow-Calf Industry,* AER- 515. U.S. Dept. of Agr., Econ. Res. Serv., Sept. 1984.

(3) Gustafson, Ronald A. "Livestock-Grain Interdependence: Implications for Policy," *Agricultural-Food Policy Review.* AFPR-1. U.S. Dept. of Agr., Econ. Res. Serv., 1977.

(4) Leman, Al. "Reproduction," *1984 Yearbook of Agriculture: Animal Health—Livestock and Pets.* U.S. Dept. of Agr., 1984, pp. 302-06.

(5) Mallinson, Edward T., and Jim A. Stunkard. "Management: Poultry," *1984 Yearbook of Agriculture: Animal Health—Livestock and Pets.* U.S. Dept. of Agr., 1984, pp. 92-104.

(6) Rea, Matt, and Gary Lucier. "Farm Income Update—1984 Estimates," *Agricultural Outlook.* AO-112. U.S. Dept. of Agr., Econ. Res. Serv., Sept. 1985, pp. 15-20.

(7) Roberts, Stephen. "Reproduction," *1984 Yearbook of Agriculture: Animal Health—Livestock and Pets.* U.S. Dept. of Agr., 1984, pp. 135-41.

(8) Stillman, Richard P. "Livestock Sector Costs and Returns Indicators." U.S. Dept. of Agr., Econ. Res. Serv., forthcoming.

(9) __________. "A Quarterly Forecasting Model of the Livestock and Poultry Economy." M.S. thesis, Virginia Polytechnic Institute and State Univ.-Blacksburg, 1980.

(10) Todd, Richard M. "Effects of Federal Grain Programs on the Livestock Sector." Federal Reserve Bank of Minneapolis, Nov. 1984.

(11) U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service. *Feed Situation.* FdS-272. Feb. 1979.

(12) Westcott, Paul C. *Aggregate Indicators in the Quarterly Agriculture Forecasting Model—Retail Food Prices.* ERS Staff Report No. AGES860916. U.S. Dept. of Agr., Econ. Res. Serv., Oct. 1986.

(13) __________. *A Quarterly Model for the U.S. Dairy Sector and Some of Its Policy Implications.* TB-1717. U.S. Dept. of Agr., Econ. Res. Serv., Apr. 1986.

(14) __________, and David B. Hull. *A Quarterly Forecasting Model for U.S. Agriculture: Subsector Models for Corn, Wheat, Soybeans, Cattle, Hogs, and Poultry.* TB-1700. U.S. Dept. of Agr., Econ. Res. Serv., May 1985.

Issues and Developments in Biotechnology: What's an Economist To Do?

Susan E. Offutt and Fred Kuchler

Abstract

The spectacular nature of many of the breakthroughs in biotechnology has generated considerable publicity and has made demands on agricultural economists for *ex ante* assessment of potential impacts. This article suggests a research agenda for evaluating the impacts of biotechnology on agricultural production. It reviews the regulatory history to identify problems unique to the application of biotechnology to agriculture.

Keywords

Biotechology, regulation, production economics

The use of biotechnology will bring about the next major episode of technological change in farming, following the mechanical and chemical innovations of the past. The proposed uses of these new techniques, whether to increase milk production or breed pesticide-resistant plants, have generated what seems to be extraordinary and unprecedented publicity. This article explores the contentious issues in the use of biotechnology for agriculture and considers what agricultural economists can and cannot do to clarify the choices to be made about new techniques in farming.

Use of biotechnologies for agriculture has raised concerns about physical safety and environmental hazards and about socioeconomic impacts of adoption as well. The deliberate release of novel genotypes into the uncontrolled environment will be involved in some applications of biotechnology to farming, in contrast to uses in other areas such as medicine. At present, the ability of scientists to predict the consequences of such release is limited. Yet, debate in the regulatory arena often centers on the level of risk and uncertainty associated with deliberate release. Concern about socioeconomic impacts has also been raised. The controversy over the ultimate effect of adoption of bovine growth hormone (bGH) on the size and number of dairy farms is a good example (see *11*).[1] The debate leading to the Food Security Act of 1985 clearly reflects the importance of the future structure of American agriculture in that the new biotechnologies will likely be significant in determining the distribution of farms by size category. The two sets of issues, physical safety and socioeconomic effects, have frequently become entangled as the courts and regulatory agencies have sought to develop guidelines for research and development of commercial applications of biotechnology. To sort through the controversies surrounding biotechnology, both sets of issues must be understood.

Agricultural economists can contribute in assessing the impacts of technology on farm size, structure, and production practices, but will have little to say in resolving questions about the new technologies' health and environmental safety. The Congress, courts, and regulatory agencies require information on the likely benefits and economic costs of new technologies to make decisions about the advisability of their use, future levels of research funding, design of farm programs, and the like. Thus, agricultural economists face a demand for *ex ante* evaluation of new production possibilities. Although technology assessment is not a new task, analyses of technological change have usually been done after adoption is complete (for example, Griliches'

Offutt is an assistant professor in the Department of Agricultural Economics at the University of Illinois-Urbana, and Kuchler is an agricultural economist with the Natural Resource Economics Division, ERS.

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

work on hybrid corn (*9*)). However, pressure now exists for analysts to evaluate the impacts of biotechnology with little knowledge about the final form of technological advance. Agricultural economists must, therefore, assess the adequacy of theoretical and empirical methods of investigation in trying to make useful contributions to decision-making.

The discussion that follows explores questions about both the health and environmental safety and socioeconomic impacts of biotechnologies. Its purpose is to help agricultural economists understand and anticipate the need for assessment of biotechnologies. At the start, we distinguish between biotechnologies as methods of inventing and the products obtained by their application. We focus on farm-level use of new technologies, although the implications for input market structure and for post-harvest processing may well be significant. Next, we review the regulatory history to highlight contentious health and environmental safety issues. We also discuss at some length deliberate release because of its importance in regulatory decisions. After exploring issues of physical safety, we consider the conduct of technology assessment by agricultural economists. We identify areas in which contributions appear to be possible and appraise the limitations to analysis. Finally we make some observations about the roles agricultural economists may usefully play in evaluating biotechnologies for agriculture.

Means Versus Ends

In economic analyses, distinguishing between new biotechnologies that represent "methods of inventing" and the products that result from these methods is useful. Although these methods of development, such as recombinant DNA, may well raise policy issues associated with environmental safety (release and uncontrolled reproduction of a novel genotype causing environmental damage), agricultural economists will be most concerned with new input and output possibilities: the end products of biotechnology research. Many, if not most, of the new biotechnologies represent new ways of producing familiar products, such as using plant cell and tissue culture to develop improved crop varieties. Other examples include plant regeneration, somatic hybridization, and embryo transfer. Few of these procedures will be carried out by farmers, although some may be provided as services by specialized technicians. Another important aspect of these techniques is their potential for accelerating the pace of technological change. For example, current breeding techniques to produce new varieties may take up to 10 years before a reliable strain is developed. With tissue culture, selection for traits is more precise, cutting the time needed in crossing and recrossing.

The end products of biotechnologies are usually more interesting to economists concerned with productivity and agricultural structure than are questions raised by the method of inventing. These end products may take the form of either inputs to the production process or new possibilities for output. One example might be enhanced versions of conventional products, such as cheaper, more effective vaccines or meat animals whose carcasses have lower fat content. Altogether new agricultural products represent another category. Commercial production of frost-inhibiting bacteria, applicable to fields and orchards, is an example of a new input. High-protein feed derived from petroleum using bioengineered enzymes is an example of a new output (but a new input to the livestock sector). Because these new products would substitute for existing ones (the bacteria for smudge pots and the petroleum feed for soybeans), they could cause abrupt changes in agricultural input industries. New industries may develop and possibly replace existing industries.

The regulatory process has attempted to determine whether the means through which biotechnologies are produced pose hazards to human health and the environment. The deliberate release of genetically engineered organisms into the environment and the possibility of their uncontrolled reproduction has generated the most debate. The existence or nonexistence of these externalities is a debate to which economists cannot contribute. However, other types of regulatory analyses (such as pesticide evaluation) attempt to compare benefits against risks. Both means and ends will be of interest to economists when these types of comparisons are made for biotechnology products.

Regulation of Biotechnology

The history of the regulation of biotechnologies is short, but stormy. A fundamental issue has been biotechnology's definition, which affects the scope of regulation. Industry favors a definition that includes "any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses" (*6*, p. 8). Viewed this way, everything man has done to domesticate plants and animals or to make bread or wine can be described as biotechnology. So long as new techniques, such as cell fusion, are considered similar to older technologies, no new regulatory issues arise.

Dr. Alan Goldhammer of the Industrial Biotechnology Association maintains, "It is important at the outset to stress that many of these new biotechnologies are simply improved versions of existing products and as such should not raise significant regulatory issues" (7, pp. 1-2). Industry would avoid regulation based on the processes used to develop or manufacture new products because that is the point at which all the newer biotechnology products are guaranteed to be different from past products. Industry fears that, if biotechnology were perceived as posing new problems, more regulations and regulatory agencies would be demanded.

In contrast, the Federal agencies involved in monitoring biotechnology have favored a more specific definition. The Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), the National Institutes of Health (NIH), the Occupational Safety and Health Administration (OSHA), and the U.S. Department of Agriculture (USDA) have all been involved. In their view, biotechnologies fall into three categories: (1) classical genetic selection or breeding for purposes such as baker's yeast production, conventional fermentation, and vaccine development; (2) the direct *in vitro* modification of genetic material, such as recombinant DNA or gene-splicing; and (3) the use of other novel techniques for modifying the genetic material of living organisms, such as cell fusion and hybridoma technology (*6*, p. 8). Regulatory agencies find a distinction useful between classical genetic selection and the newer techniques (described in the last two categories) because such a distinction emphasizes the source of the potential environmental risks.

Responsibility for the oversight of federally funded research on genetic engineering originally rested with a committee operating under the auspices of NIH. As the field of inquiry was broadened beyond medicine, other agencies became involved by reinterpreting existing legislation on regulatory responsibilities. In June 1986, the White House Office of Science and Technology Policy issued rules describing a coordinated framework for the regulatory assessment of biotechnology that formalized many of the previously evolved relationships and responsibilities. NIH will continue to monitor research activities, although other agencies are responsible for overseeing specific application. USDA will regulate gene-altered animal vaccines, diseases, plant materials, and plant pests. USDA will also continue research in these areas. EPA has general responsibility for overseeing genetically engineered microbes, but it will share these duties with USDA when agricultural crops are involved. FDA is responsible for animal drugs and human health care products. OSHA will look after genetically engineered products used in the workplace.

Agriculture is likely to pose the thorniest regulatory problems of all the industries affected by biotechnology. Public concern over biotechnologies was initially stirred in Cambridge, MA, when citizens feared a laboratory scientist might accidentally allow a gene-altered micro-organism to escape and contaminate the environment. In agriculture, release of novel micro-organisms is certain for many biotechnology products. Such products are designed so that farmers can release quantities of micro-organisms, attempting to change biological processes to suit the purposes of agricultural production.

Regulatory experience is short. However, the record does show that the development of agricultural technologies has been successfully contested, based on their potentially adverse environmental impacts. Developers of four genetically engineered agricultural products—a swine vaccine, a frost-inhibiting bacteria, a soil organism with insecticidal properties, and a bovine growth hormone—have requested permission for field tests of their products. Each product has made news many times as courts have found regulatory procedures inadequate. In contrast, four pharmaceutical products involving genetic engineering have been successfully registered with FDA. Insulin, human growth hormone, interferon, and a hepatitis vaccine are now produced commercially. The advisability of the deliberate release of gene-altered organisms has created a debate unique to agriculture.

Biologics Corporation, the manufacturer of a vaccine for the swine virus, pseudorabies, has won, lost, and now regained its USDA registration to sell the product. The vaccine is created by gene deletion and is a weakened, but live, form of the pseudorabies virus. It was alleged that USDA had not followed its own guidelines for assessment in granting the registration. The Foundation on Economic Trends, headed by Jeremy Rifkin, sued, and the registration was temporarily canceled but subsequently reissued. Although the Foundation's complaint was filed on the basis of improper regulatory procedure, the real issue centered on the potential hazards from deliberate release of genetically altered organisms. In reissuing the license, USDA argued that deleting the single gene prevented the virus from producing an enzyme it required to multiply and spread.

Frostban is a bacterium designed to inhibit the formation of frost on plants. This gene-deleted product is identical to the naturally occurring bacteria that inhabit plants, except that it is missing the part of its genetic code that triggers production of an ice-nucleating protein that promotes frost. No application for permission to field-test Frostban has yet been successful. In 1984, a University of California test was prevented by a court ruling that NIH had illegally given its approval. In late 1985, a private company, Advanced Genetic Sciences (AGS), obtained an experimental use permit from EPA. EPA subsequently revoked the permit because of questions raised about the experimental procedure. In August 1986, University of California scientists again proposed a test of the bacteria, but a temporary restraining order has delayed the test, at least until spring 1987, while an environmental impact statement is prepared. Evaluation of the potential risks of releasing a unique organism was at the crux of the debate.

Monsanto has developed a soil microbe genetically engineered to have insecticidal properties, but it has also failed to gain EPA approval for experimental field testing. This bacterium is altered to carry additional genes, making the organism toxic to some insects. The engineered microbe has the toxicity of the insect pathogen, *Bacillus thuringiensis* Berliner, commonly known as Bt. Its purpose is to reduce the need for synthetic organic chemicals to control corn rootworm. EPA's decision is still pending while more information on the behavior of the altered organism is gathered.

Bovine growth hormone (bGH) raises an entirely different set of questions. Unlike other agricultural biotechnologies, bGH does not require deliberate release of a genetically engineered organism. The development of a process for its industrial manufacture solved the problem of producing large quantities of the substance inexpensively. By injecting purchased bGH, dairy farmers can theoretically augment the flow of bGH that dairy cows normally produce. If administered at the correct point in the lactation cycle, bGH could markedly increase milk production. Because bGH is a naturally occurring substance, its use and release into the environment does not pose the risk of changing ecological processes by introducing a new organism. The risks considered by the regulatory process include the potential for damage to dairy cow health and the question as to whether milk or meat products would contain substances harmful to consumers. If these risks did exist, controlled use of bGH could probably limit their effects. In contrast, the deleterious effects of introducing new organisms are not always controllable. Apart from the question of deliberate release, the regulatory issues by bGH have been more like the issues raised by human health products rather than the other agricultural biotechnology products. However, concerns over how bGH might affect both the trend toward fewer and larger dairy farms and the costs of farm programs could delay the commercial release.

Deliberate Release

The deliberate release of gene-altered organisms raises many of the same problems as use of toxic chemicals: how chemicals are changed and where they will be moved, and hazards, exposure, and effects on ecosystems (*15, 16*, p. 60). However, the possibility of uncontrolled reproduction of some genetically engineered organisms makes the problem more like one of introducing an exotic species. Although many such introductions fail, there have been notable exceptions, including the gypsy moth, starling, and kudzu vine in the United States and the European rabbit in Australia. The important questions about introduced exotics are whether they will disrupt any other ecological processes or whether they will pose any health hazards. Before these questions are asked, one has to know whether the exotics will survive, and if so, whether they will reproduce. To answer these questions and forecast the impact of introducing exotics, biologists have classified exotic species four ways: (1) slightly modified forms of resident types; (2) forms that exist naturally in the target environment, but which require continual supplemental support or continual replacement to be sustained; (3) forms that exist naturally elsewhere, but which have not previously reached the target environment; and (4) genuine novelties (*16*, p. 59). This classification scheme is useful in analyzing the deliberate or accidental release of genetically engineered organisms because it highlights the problems in forecasting externalities.

The three genetically engineered agricultural products that involve release of an organism may be categorized despite little or no actual experience with two of them. Frostban is identical to naturally occurring bacteria, except for a deleted gene. Because Frostban is produced by gene deletion, the altered organism might be weakened and might need continual support or replacement, as described in category (2). Gene deletion makes the bacteria unable to invade plants through frost damage. Hence, Frostban might be unable to compete with natural bacteria in the long run. The pseudo-rabies vaccine, also produced through gene deletion, appears to fall into category (2). The weakened form of the virus makes it suitable as a vaccine. The

Monsanto soil toxin represents a genuine novelty and belongs in category (4).

The need for regulation of gene-deleted organisms has been debated. Some advocates have seen the gene-deleted products as harmless, on the theory that the engineered organisms are weakened and cannot survive because some of the characteristics allowing them to survive—the tools with which they evolved—have been taken away. However, geneticist Jonathan King at the Massachusetts Institute of Technology has said: "It is a medieval scientific view that a deletion is automatically less risky" (*20*). He argues that deleting a single gene can produce major changes in the biological activity of micro-organisms. DNA molecules exist in a delicate balance, with one gene or group of genes modifying the activity of other genes or groups of genes. Removing a gene can upset the balance, causing microbes to mutate and multiply, with unforeseen consequences.

Although one organization, the Foundation on Economic Trends, has brought many of the suits to halt testing of gene-altered products, the broader scientific community has raised related issues. Some scientists have opposed the Administration's new rules on biotechnology that do not subject products created through deletion or alteration of regulator genes to stringent review. Liebe Cavalieri of the Sloane-Kettering Institute has called the Administration's position "scientifically undefensible" (*19*). Because of the uses to which biotechnology will be put in agriculture, the issues of deliberate release and of its use in animals and food products will probably remain contentious. Without more experience, researchers cannot accurately predict health and environmental impacts. However, opposition has so far successfully blocked most experimental field tests.

Technology Assessment: A Starting Point

The use of biotechnologies raises a few new issues for assessment by agricultural economists, but mainly reintroduces some old ones. The scope of traditional concerns is reflected in a recent study from the Office of Technology Assessment (OTA). Using the OTA work as a starting point, we suggest a broader scope for assessment and identify key issues and methods in the economic analysis of biotechnologies.

The OTA study, *Technology, Public Policy, and the Changing Structure of American Agriculture* (*25*), provides a good starting point for analyzing biotechnologies in agriculture. It considers the impacts of new informational and biological technologies, which include a wider range of techniques (for example, personal computers and conservation tillage) than the biotechnologies we consider here. OTA's main concern is with anticipated changes in the structure of agriculture, as defined by the number and size distribution of farms.

OTA argues that the new technologies will be adopted by well-financed, innovative farmers who are presumed to run the larger farms. These farmers will be advantaged either because of their ability to make the initial capital outlays required for adoption or by their superior management skills, which are needed to take full advantage of the new technologies. OTA concludes that the future holds a bimodal distribution of very large and very small farms. The demise of middle-size farms (identified as the backbone of U.S. agriculture) can be averted only by public policy intervention that directly targets the endangered farmers. Current farm policies are seen to exacerbate, or at least not to retard, this tendency toward resource concentration in agriculture.

OTA's conclusions, however, must be viewed with caution. The link between farm size and ability or willingness to adopt new technologies is not well documented. Cited literature pertains to experience in developing countries or to use of mechanical technologies, neither of which is necessarily relevant to the future of American agriculture (*13*). Even if all farmers were equally willing and able to pay for new technologies, then for large farmers to benefit, most of the technologies would have to exhibit scale bias. Although mechanical technologies, such as the large combines adopted since World War II, may have displayed such scale-dependence, it is not clear that the new technologies will.

Using the OTA analysis as a starting point, we can identify two important areas for further study. First, are only large farmers willing and able to innovate? How does managerial ability vary with size? Will these new technologies really require large initial capital investments? (Even in the OTA study itself, the results are mixed.) The structure of the market for these new technologies, particularly the power of nonfarm firms as input suppliers, should also be evaluated (*24*, p. 1177). Second, what are the characteristics of the technologies? How can scale-dependence be predicted? Would economies of scale arise out of technical conditions of production or from pecuniary sources? Day has noted the importance of the scale issue in evaluating public research priorities (*2*, p. 999).

Further Issues in Biotechnology Assessment

The scope for assessing new biotechnology products goes beyond a consideration of their scale dependence. Although evaluation of decisions to invest in research into new technologies would not be a new task for agricultural economists, development and use of biotechnologies may highlight the importance of equity as well as efficiency criteria in project selection (*1*, p. 960). The unprecedented nature of the potential environmental impacts of the use of gene-altered organisms in farming will present new research problems. Traditional methods for studying innovation will be useful for new biotechnology-based products, although the demand for *ex ante* analysis may create new challenges. Finally, considering the financial stress in the agricultural sector, economists must carefully explain profit and output implications of new products and technologies.

Research Evaluation

Public and private funding for research ultimately determines what new technologies and products are available to the agricultural community. In explaining the outcome of the decisionmaking process, Hayami and Ruttan's induced innovation hypothesis predicts that changes in factor ratios brought on by technological advance will be a function of changes in relative factor prices (*10*). Have the recent innovations of biotechnology been induced in this way? If biotechnologies are land-saving, as Hayami and Ruttan suggest (*10*, p. 75), was their development encouraged by the runup in farmland values in the seventies? Does the recent decline in the land market affect the likelihood of adoption of these innovations? Kislev and Peterson have criticized the induced innovation approach for its failure to distinguish between technical change that is external to farming (as occurs in input manufacturing) and change that is internal. Distinguishing between the two types of change affects the responsibility one assigns to the agricultural research system for the impacts of technological advance (*12*, p. 562).

The induced innovation model implies reliance on market signals to spur appropriate technology development. However, the predictive ability of the induced innovation model may be questioned, if society applies criteria other than those embodied in market signals to the selection of new technologies. Concern over U.S. export performance in world markets means that transferability of new production technologies to potential competitors or customers may become a consideration in development. Concern over the preservation of farming and rural life, in addition to worries about resource conservation, indicates the importance society may attach to amenities whose values are not well reflected in market prices. Bonnen (*1*) has suggested that the role of the social sciences should be expanded when analysts evaluate research supporting innovations in production agriculture. More emphasis on institutional and human capital impacts of new technologies would be appropriate. However, Shumway has questioned the usefulness of economists' *ex ante* quantifications of research benefits in guiding decisions and has stressed the importance of the individual scientist in problem selection (*23*).

Risk Assessment

The novel nature of some of the products of biotechnology puts a new slant on risk assessment for agriculture. The use of biotechnology in agriculture presents potential problems associated with the deliberate release of genetically engineered organisms into the environment. The first difficulty in dealing with such a release is encountered when regulations are designed (see *17*). In principle, many of these issues are similar to those associated with externalities in that they involve outcomes not currently valued by the market. Questions about the safety of these new products are currently being dealt with by the judicial system. Ultimately, tort law stands to be the final arbiter in the event that compensation is sought for damages due to injury from the use of these products (see *22*).

There is no reason why resolution of such questions should be the sole province of the courts or why lawyers should be the principal actors in resolving these issues. By broadening their conception of risk assessment, agricultural economists could have an educational role in presenting alternative scenarios of the measurable economic welfare gains and losses to society with and without such new agricultural technologies. W.D. Ruckelshaus, the former EPA administrator, has argued for a broad role for regulatory agencies in evaluating and resolving problems associated with the use of genetically engineered organisms in the open environment (*18*). The potential contributions of economists to such risk management have not yet been identified.

Adoption and Production Analyses

A broad area of inquiry concerns adoption and production studies for new technologies. Three points are of particular interest here: the assessment of the distributional impacts of new technologies, prediction of the likelihood of adopton of new biotechnology products, and the ability of economic analysis to deal with changes in product quality.

The OTA study suggests that the distributional effects of adoption of new agricultural technologies will be more important than ever. Concerns about the structure of agriculture have been at the forefront of recent farm and food policy debates. Agricultural economists will need to provide decisionmakers with more specific information about the identity of gainers and losers from technological change. Researchers working in developing countries (see *21*) have more frequently confronted such equity issues than have those in the United States.

To go beyond a tautological separation of farmers into innovators (early adopters) and laggards (late adopters), analysts will have to consider differences in managerial skill, economic circumstance, climate, and resource endowment. Such information is crucial to predicting the success of adoption of new technologies that depend heavily on the level and quality of complementary inputs for maximum gain. Feder's study of interrelated agricultural innovations (again in a developing country context) is a useful reference (*4*). Several studies have suggested means of evaluating the adoption decisions of farmers *ex ante*. Goodwin, Sanders, and de Hollanda use simulation models of farms to evaluate the effect of risk preferences on adoption decisions (*8*). Yassour, Zilberman, and Rausser present a more general framework, allowing new technologies' impacts to be reflected in a variety of stochastic distributions for crop yield (*26*). The immediate problem with this approach to evaluating biotechnologies is often the analyst's ignorance of the nature of yield impacts. However, experiment plot data, when available, may fill this void until commercial introduction. Flood, McCamley, and Schneeberger have recently used a mean-variance framework to evaluate the congruence between yield test results and farmers' variety adoption decisions (*5*). Lesser, Magrath, and Kalter present a method for *ex ante* projection of adoption rates of bGH (*14*). These analyses demonstrate how the existing methodological framework can be used to evaluate the products of biotechnology.

To be useful, *ex ante* analyses will have to be specific to individual technologies or packages of technologies. Treating technological change as a homogeneous force (as when it is represented empirically by a time trend) will not help make predictions. The challenge will be to anticipate new products as they approach commercial introduction. For some products, early warning for economists is provided through the regulatory system. For others, a system capable of monitoring products emanating from a broad spectrum of private and public groups worldwide is needed. The technology group of USDA's Economic Research Service has begun to consider this issue, investigating how Agricultural Research Service reporting might be used to track emerging technologies. The United Nations Industrial Development Organization has initiated a monitoring service as well.

Biotechnologies will produce both enhanced versions of existing products as well as completely new ones. Economic theory provides a limited framework for dealing with changes in the quality of goods or with the introduction of new goods (this may sometimes be viewed as a continuum rather than as two separate problems). Hedonic analysis may help identify and value characteristics of new or enhanced agricultural products. On the supply side, production theory offers no sophisticated way to predict shifts in the production function or in the values of the parameters after technological change. As Kislev and Peterson point out, product innovation creates an identification problem because the distinction between changes in input quality and technological change may be arbitrary (*12*, p. 564). Separating these issues presents a challenge to empirical estimates of productivity impacts of new biotechnology-derived products.

Impacts on Output

Changes in orientation of agricultural research have presented another challenge to the economic analysis of new technologies. The old research precept of seeking to have "two blades grow where one grew before" is no longer unanimously held. Instead, agricultural research priorities now focus on what is deemed cost-reducing rather than yield-enhancing new technologies. To an economist, these changes are two sides of the same coin because both kinds of technological change result in an increase in output, except in the case of perfectly inelastic demand. This situation is the analytical consequence of profit maximization. The result that technological change fails to increase output and instead increases only profits is never obtained. Marginal cost, and so supply curves, always shift downward and to the right with the adoption of such new technologies.

In competitive markets free of Government programs and intervention, technological change offers greater profits to early adopters and greater production and concomitant lower prices to consumers. However, commodity programs designed to maintain farm prices and income further complicate technology assessment. Predictions of inevitable output increases from technology development are not very appealing to agricultural research administrators in an era of surplus production. These scientists must cope with criticism from those who argue that agricultural research exacerbates the contemporary overcapacity problem. Given that U.S. market share and price have declined steadily in recent years, it seems counterintuitive to argue that output must be increased to maintain competitiveness in world markets. However, because the prediction of ever-increasing output stems from fundamental assumptions of economic analysis, either the conviction of economists that this result is inevitable should be communicated to policymakers or the method of analysis should be reconsidered.

Conclusions

The use of the products of biotechnology in agriculture poses difficult problems for those who develop Federal regulations to ensure environmental health and safety. The deliberate release of genetically engineered organisms is a particular area of conflict in risk management. Litigation challenging the adequacy of regulatory safeguards can slow or prevent approval for field-testing or commercially selling gene-altered products. Predicting the timing of the availability of some products is thereby complicated. The number of regulatory agencies involved in evaluating products for agriculture (USDA, EPA, FDA) creates even more problems.

The spectacular nature of many breakthroughs in biotechnology has generated considerable publicity and has made demands on agricultural economists for an *ex ante* assessment of the potential impacts. Some products developed using these new techniques do present unique problems in the assessment of human health and environmental risk. Although some products will represent completely new inputs or outputs, several others will simply be enhanced versions of familiar products. In any event, the pace of technological change in agriculture may be accelerated because the new techniques often allow short-cuts in conventional plant and animal breeding and selection.

Agricultural economists enter treacherous, but not necessarily uncharted, waters in considering the potential effects of these new technologies. Predictive ability, however, may be limited. Drucker has argued that such impacts cannot be known in advance and that efforts in that direction only "guarantee full employment to a lot of fifth rate science fiction writers" (*3*, p. 54). Nonetheless, the unprecedented rate of change will mean that, if agricultural economists are to have much useful to say about the impacts of new technologies, they will need to do *ex ante* analysis. The most urgent informational needs of decisionmakers now appear to place demands on the weakest skills of agricultural economists. Evaluations of the risks and benefits of environmental release of genetically engineered organisms and of the institutional and human capital aspects of technological change are required. Although the insight gained from more conventional production analyses will be of use, exclusive use of this approach in the future will surely curtail the participation of agricultural economists in decisions governing the choice of biotechnology-based products.

References

(1) Bonnen, James T. "Historical Sources of U.S. Agricultural Productivity: Implications for R & D Policy and Social Science Research," *American Journal of Agricultural Economics*, Vol. 65, 1983, pp. 958-66.

(2) Day, Lee M. "Research and the Family Farm: Implications for Agricultural Economics Research," *American Journal of Agricultural Economics*, Vol. 63, 1981, pp. 997-1004.

(3) Drucker, Peter F. *Toward the Next Economics and Other Essays*. New York: Harper and Row, 1981.

(4) Feder, Gershon. "Adoption of Inter-related Agricultural Innovations: Complementarity and the Impacts of Risk, Scale, and Credit," *American Journal of Agricultural Economics*, Vol. 64, 1982, pp. 94-101.

(5) Flood, Margaret, Francis McCamley, and Kenneth Schneeberger. "Mean-Variance Efficiency as an Approach to Evaluate Farmer Adoption of Crop Technology,"*North Central Journal of Agricultural Economics*, Vol. 7, 1985, pp. 33-40.

(6) General Accounting Office. "Biotechnology: Agriculture's Regulatory System Needs Clarification." GAO—RCED 86-59. Mar. 1986.

(7) Goldhammer, Alan. "Perspectives on EPA Regulation of Biotechnology Products." Speech presented at the Washington International Conference on Biotechnology, Alexandria, VA, Apr. 1986.

(8) Goodwin, Joseph B., John H. Sanders, and Antonio Dias de Hollanda. "*Ex Ante* Appraisal

of New Technology: Sorghum in Northeast Brazil," *American Journal of Agricultural Economics*, Vol. 62, 1980, pp. 737-41.

(9) Griliches, Zvi. "Hybrid Corn: An Exploration in the Economics of Technical Change," *Econometrica*, Vol. 25, 1957, pp. 501-22.

(10) Hayami, Yujiro, and Vernon W. Ruttan. *Agricultural Development: An International Perspective*. Baltimore: The Johns Hopkins Univ. Press, 1985.

(11) Kalter, Robert J., and others. *Biotechnology and the Dairy Industry: Production Costs and Commercial Potential of the Bovine Growth Hormone*. Ag. Econ. Res. No. 84-22. Cornell Univ., Dec. 1984.

(12) Kislev, Yoav, and Willis Peterson. "Induced Innovations and Farm Mechanization," *American Journal of Agricultural Economics*, Vol. 63, 1981, pp. 562-65.

(13) Kuchler, Fred, and Susan E. Offutt. "Review of Technology, Public Policy, and the Changing Structure of American Agriculture," *American Journal of Agricultural Economics*, Vol. 68, 1986, pp. 764-66.

(14) Lesser, William, William Magrath, and Robert J. Kalter. "Projecting Adoption Rates: Application of an *Ex Ante* Procedure to Biotechnology Products," *North Central Journal of Agricultural Economics*, Vol. 8, 1986, pp. 159-73.

(9) Levin, Simon. "The Risk Assessment/Confidentiality Balance." Paper presented at the Washington International Biotechnology Conference, Alexandria, VA, Apr. 1986.

(16) __________, and Mark A. Harwell. "Environmental Risks and Genetically Engineered Organisms," in *Biotechnology: Implications for Public Policy* (ed. Sandra Panem). Washington, DC: The Brookings Institution, 1985.

(17) McGarity, Thomas O. "Regulating Biotechnology," *Issues in Science and Technology*, Vol. 1, Spring 1985, pp. 40-56.

(18) Ruckelshaus, William D. "Risk, Science, and Democracy," *Issues in Science and Technology*, Vol. 1, Spring 1985, pp. 19-38.

(19) Schneider, Keith. "Biotechnology Regulations Are Signed by Reagan," *The New York Times*, June 19, 1986.

(20) __________. "Eased Rules on Gene Engineering Weighed," *The New York Times*, May 22, 1986.

(21) Scobie, Grant M., and Rafael Posada T. "The Impact of Technical Change on Income Distribution," *American Journal of Agricultural Economics*, Vol. 60, 1978, pp. 85-90.

(22) Shavell, Steven. "Uncertainty Over Causation and the Determination of Civil Liability," *Journal of Law and Economics*, Vol. 28, 1985, pp. 587-609.

(23) Shumway, C. Richard. "Subjectivity in *Ex Ante* Research Evaluation," *American Journal of Agricultural Economics*, Vol. 63, 1981, pp. 169-73.

(24) Sundquist, W.B. "Impacts of Emerging Technologies on U.S. and Third World Agriculture: Discussion," *American Journal of Agricultural Economics*, Vol. 67, 1985, pp. 1176-77.

(25) U.S. Congress, Office of Technology Assessment. *Technology, Public Policy, and the Changing Structure of American Agriculture.* OTA-F-285. Mar. 1986.

(26) Yassour, Joseph, David Zilberman, and Gordon C. Rausser. "Optimal Choices among Alternative Technologies with Stochastic Yield," *American Journal of Agricultural Economics*, Vol. 63, 1981, pp. 718-23.

Research Review

U.S. Competitiveness in the World Economy

Bruce R. Scott and George C. Lodge (eds.). Cambridge, MA: Harvard University Press, 1985, 543 pp., $16.95.

Reviewed by Stephen W. Hiemstra

The decline of key U.S. manufacturing industries has focused public attention on the competitiveness of U.S. exports. The mid-1986 advent of a trade deficit in agricultural products turned heads throughout the Nation. These events provide ample motivation to review a book on U.S. competitiveness.

U.S. Competitiveness in the World Economy is a book of readings that evolved out of a colloquium series sponsored by the Harvard Business School (HBS) during 1983-84.[1] These readings represent the best papers presented in this series and include papers on competitiveness issues and industry studies. Most are authored by HBS faculty. The readings were reviewed by a cross-section of academic, industry, labor, and government leaders and are edited so that they contribute to a common understanding of competitiveness. Consequently, it is more useful to grapple with the issues raised by the readings taken together than to evaluate them individually.

A key theme running through these readings is that "competitiveness is more and more a matter of strategies, and less and less a product of national endowments" (p. 5). This emphasis on strategies[2] suggests that the effect of natural resource endowments on a country's export product mix is influenced by the choice of technology, prices, market institutions, and public policies. From this perspective, competitiveness is not window-dressing on the concept of comparative advantage. Economies of scale are considered more important than resource endowments in determining a nation's export product mix. Strategic innovators obtain a lower cost of production by targeting growing markets before their competitors and by moving more rapidly down the learning curve. For the authors, "national competitiveness refers to a country's ability to create, produce, distribute, and/or service products in international trade while earning rising returns on its resources" (p. 3).

The papers include: (1) "U.S. Competitiveness: Concepts, Performance, and Implications" by Bruce R. Scott; (2) "National Strategies: Key to International Competition" by Bruce R. Scott; (3) "Sustaining U.S. Competitiveness in Microelectronics: The Challenge of U.S. Policy" by William F. Finan and Annette M. LaMond; (4) "The Very High Speed Integrated Circuit Program: Lessons for Industrial Policy" by Michael Y. Yoshino and Glenn R. Fong; (5) "U.S. Competitiveness in Global Industries: Lessons from the Auto Industry" by Malcolm S. Salter, Alan M. Webber, and Davis Dyer; (6) "Textiles and Apparel: A Negotiated Approach to International Competition" by Stanley Nehmer and Mark W. Love; (7) "Restructuring Petrochemicals: A Comparative Study of Business and Government Strategy to Deal with a Declining Sector of the Economy" by Joseph L. Bower; (8) "International Competitiveness of American Industry: The Role of U.S. Trade Policy" by Alan W. Wolff; (9) "Technology as a Factor in U.S. Competitiveness" by Harvey Brooks; (10) "Competitiveness in the World Economy: The Role of the U.S. Financial System" By Philip A. Wellons; (11) "Savings, Investment, and Government Deficits in the 1980s" by Benjamin M. Friedman; (12) "Competitiveness: The Labor Dimension" by D. Quinn Mills and Malcolm R. Lovell, Jr.; (13) "Enhancing Competitiveness: The Contribution of Employee Relations" by D. Quinn Mills and Malcolm R. Lovell, Jr.; and (14) "The Pursuit of Remedies" by George C. Lodge and William C. Crum.

The reviewer is an economist with the International Economics Division, ERS.

[1] A colloquium held in 1985 focused on agriculture. See Federal Reserve Bank of Kansas City, *Competing in the World Marketplace: The Challenge for American Agriculture* (Kansas City, MO, 1985).

[2] The focus on strategies stems from the HBS approach to corporate management generally, as exemplified in Michael Porter's *Competitive Strategies* (New York: McGraw-Hill Company, 1980).

The Japanese example figures prominently throughout the book. Two key features of the Japanese national strategy are highlighted. First, the Japanese strategy is "growth/productivity/opportunity oriented" rather than "distribution/security/resource oriented" (p. 72). In other words, Japanese institutions encourage hard work and savings rather than equal opportunity and consumption. Second, the Japanese Ministry of International Trade and Industry uses two criteria for selecting industries for support: (1) the industry should have a high income elasticity, and (2) the industry should exhibit a potentially high rate of return to technological sophistication (p. 98). The first criterion suggests that the industry possesses a growing market, and the second that it makes use of Japan's most abundant resource: skilled labor. The structure of Japanese financial markets, labor institutions, and social policy all reinforce the Japanese strategy. In contrast to the Japanese model, U.S. export strategy is a byproduct of a laissez-faire trade policy hampered by incompatible domestic policies designed to promote goals other than competitiveness.

The remedy for the U.S. competitiveness problem is a radical restructuring of American society. "To regain our national competitiveness, government, business, and labor leaders must inspect a number of cherished but partially antiquated assumptions about international trade, domestic government, management-labor relations, and the rights and duties that accompany membership in American Society" (p. 480). In reviewing congressional proposals, the authors see some merit in each, although all fail to address "the fundamental assumptions and priorities that have caused America's competitive failure" (p. 490).

In evaluating this line of reasoning, one sees clearly that technological change plays a leading role in determining the market where strategic planning will pay off. The Japanese have specialized in producing for selected high-technology markets.[3] Since this is the basis for the Japanese strategy, the authors never confront the issue as to whether a larger nation, such as the United States, could be expected to support its growth based on extraordinary growth in a limited number of markets. If the growing markets are small or the improvements in technology/efficiency are relatively minor relative to the size of a nation's economy, then specialization cannot be expected to yield improved growth and a diversification strategy may be more appropriate. In view of the radical prescription the authors propose, it is appropriate for analysts to evaluate the Japanese strategy more closely.

U.S. Competitiveness in the World Economy is a high-quality reader, likely to interest a wide audience from university students to specialists in international trade. The papers are readable, pragmatic, and scholarly. Although not the last word on the subject, this book is likely to remain the focus for discussions of competitiveness for many years.

---

[3] The Japanese competitive strategy is a logical extension of the product cycle hypothesis. See Edwin Mansfield, *Technological Change* (New York: W.W. Norton &Company, Inc., 1971).

The Cult of Information

Theodore Roszak. New York: Pantheon Books, 1986, 238 pp., $17.95

Reviewed by L. Joe Moffitt

Dictionaries 25 years ago defined information as "knowledge communicated or received." More recent dictionaries offer an alternate meaning, for example, "data that can be coded for processing by a computer." Roszak's book traces the evolution of the concept of information and the forces that have contributed to the development of the Information Economy, an economy in which the production and exchange of information is a major activity.

Roszak links the origin of the current prominence of information in economic affairs to Norbert Wiener's post World War II founding of the field of cybernetics, Claude Shannon's quantitative definition of information, the early successes of computing machines such as UNIVAC, and the ensuing work in biology and artificial intellingence (AI). These developments are portrayed by Roszak as having triggered a sense of discovery and an enormous optimism among decision theorists and other scientists, as exemplified in a statement attributed to Herbert Simon identifying information with the basis of life itself: "the programmed computer and human problem solver are both species belonging to the genus 'Information Processing System.' "

According to Roszak, the mystique that has developed around the concept of information as the result of enthusiasm generated by research in communications, biology, and AI, by sparkling electronic devices that process information, and by the hyperbole of advertisers and merchandisers has promoted a cult-like atmosphere that pervades the production and marketing of information. The membership of the cult includes major corporate interests, government agencies, the scientific establishment, and, increasingly, the educational system. Roszak maintains that, in the present climate, membership in the cult can grow simply because of the vogue that has been lent to the word information.

Roszak cautions that his ideas are not intended as a focal point for "computerphobes." In fact, he expresses respect for information processing. However, his main contention is that the AI view of knowledge as the result of information processing is incorrect. He regards ideas as the result of a human process apart from mechanical permutations of information. Acquiescence to the AI model presupposes a society that produces and processes increasing amounts of information, defined as computer-codable messages, in a futile pursuit of knowledge. Roszak's premise also leads him to reject more clever software as a solution to the data glut because he sees the glut itself as unnecessary; that is, it results from social forces distinct from considerations of economic efficiency. He recommends demystification of the concept of information and careful scrutiny of the legitimacy of information-processing functions by public and academic administrators.

Elements of this book remind me of an undergraduate colloquium in which a past president of the American Economic Association lamented that the overuse of mathematics in economics was "largely an excuse for thinking." Although such abuses doubtless occur, most professional economists clearly use mathematical models as appropriate adjuncts to creative problem-solving. If Roszak is correct, the aura surrounding information has permitted profit-seeking hucksters to identify information processing not as an adjunct to thinking but as a substitute for thinking so far as public perception is concerned. He identifies the public policy impacts of this perception in education, national defense, and other areas. Finally, he warns that the educational and scientific communities are, however unwittingly, becoming members of the information cult.

Roszak also provides some good entertainment. I enjoyed reading his account of the role of the counterculture in the development of California's Silicon Valley. His description of Japanese attempts to link extrasensory perception to AI, which he dubs "artificial clairvoyance," is particularly humorous.

The reviewer was formerly an agricultural economist with the Natural Resource Economics Division, ERS. He is now an associate professor in the Department of Agricultural and Resource Economics at the University of Massachusetts-Amherst.

Breadlines Knee-Deep in Wheat: Food Assistance in the Great Depression

By Janet Poppendieck. New Brunswick, NJ: Rutgers University Press, 1986, 306 pp., $30.00.

Reviewed by Tom Fulton

Newspaper articles recount how nonprofit groups can glean fantastic amounts of edible foodstuffs from fields previously harvested. Anger is similarly aroused when edible fruits or vegetables are destroyed because of slight blemishes or because they are too small. Yet, other articles in the same newspapers tell of farmers' leaving farms, unable to make a living from agriculture despite record harvests. At no time in U.S. history was this paradox more acute than during the Great Depression. This paradox of want amid plenty is the essential theme of *Breadlines Knee-Deep in Wheat.*

The book, a product of Poppendieck's doctoral dissertation, places the paradox of want amid plenty within the context of America in the twenties and thirties. After enjoying unprecedented prosperity during World War I as food suppliers to the world, farmers found themselves after the war with a rapidly declining export market as Europe's farmers-turned-warriors returned to farming. The Great Depression, for America's farmers at least, began a decade before it began for the rest of society.

When agriculture is seen as an essential underpinning to the rest of America's economic structure, what was happening should have been viewed with more alarm than it was. Americans in the twenties were lulled by a stock market that showed unprecedented gains day after day, while requiring those who participated to put up as little as 10 percent in cash. That millions were unable to look beyond the smoke and mirrors of Wall Street and see the declining conditions of essential industries, like agriculture, which underpin the economic structure, demonstrates a shortsightedness that pervaded the optimism of the decade. For the same reason, Poppendieck's book fails the reader.

The book turns too soon from an examination of the intertwining of economics and politics of surplus production and welfare relief, both of which would have been of great interest to many, to a recitation of the mechanics of the Federal relief effort. Such stories have been told before (the Praeger series comes to mind) and serve a much smaller audience than would a study with a wider scope.

In fairness, however, *Breadlines* accurately portrays the Federal response both to conditions of surplus agricultural production and to the hunger that the Government was so ill-equipped to deal with.

The reviewer is a social science analyst with the National Economics Division, ERS.

Food Policy: Frameworks for Analysis and Action

C.K. Mann and B. Huddleston (eds.). Bloomington: Indiana University Press, 1986, 243 pp., $22.50.

Reviewed by Robert E. Christiansen

This collection of essays is brought together, in the words of one of its editors (C.K. Mann), "as part of an effort to encourage interaction and dialogue among food policy analysts and practitioners. . . . The book seeks to link disciplines within the context of food policy analysis." The volume contains 27 papers and is divided into two parts: "Frameworks for Food Policy Analysis" and "Approaches to Developing National Food Policy Capabilities." The first part contains a number of perspectives on food policy, while the latter concentrates on three case studies of food policy projects in Thailand, Kenya, and Tunisia. The number of articles limits this review to highlighting especially interesting essays and describing the book's strengths and weaknesses.

The book itself is of limited value. The editors have tried to bring together a wide range of interests, from livestock potential to issues of political economy. As a result, the individual articles tend to be too short. The range of topics requires better integration than the editors have provided. For example, articles on microcomputers in Tunisia and on the livestock option for developing countries cannot be expected to stand on their own. They need to be put into a context, so the reader will understand their relevance to the broader subject of food policy.

Four "frameworks" for food policy analysis are covered in the first part of the book: production, nutrition, politics, and trade. Peter Timmer sets the stage for each of these perspectives. He argues that a successful food system/policy is difficult to achieve, because of the problems of integrating the necessary components of any food policy: household behavior by both producers and consumers, a macroeconomic policy environment, and an international trade policy. Timmer stresses the critical dependence of a successful food policy on an appropriate macroeconomic environment, which becomes a necessary, but not sufficient, condition for success. One of the frustrations is the conflict between specific policies designed to help the household and macroeconomic policy. Adequate food supplies for low-income families frequently require price subsidies or other policies that macroeconomic planners view as "distortions." Timmer points out that most macroeconomic reform packages call for eliminating such policies, leaving food policy in a quandary.

The three articles under the heading, "Production Aspects of Food Policy," concern the role of crops (Gomez), livestock in agricultural systems (Pino), and women in production (Mencher). Gomez attempts to "provide an analytical framework for evaluating the existing and potential capacity of crops to supply the nutritional requirements of an increasing world population." Instead, the article briefly discusses the technologies currently available for meeting increased food needs, for example, improved varieties and intensive cropping. Pino focuses on the role of livestock in production systems, claiming that it can play an important role in meeting food needs. However, the article serves mostly to remind the reader that livestock production is an option, but offers no solutions to problems such as the peasants' view that "animals in the system are secondary" to plant crops.

Mencher's article addresses: (1) ways in which women are involved in agriculture in different regions of the world, (2) ways in which women's participation in agriculture is affected by various institutional arrangements, and (3) the role of women in household maintenance and survival. Mencher's article is especially interesting, because it provides a valuable framework for viewing the problems of women in traditional agricultural systems. However, like others in this volume, Mencher's article suffers from a lack of development, presumably due to space restrictions. For example, Mencher's description of women's role in agriculture in various regions is limited to five pages, which does not begin to do justice to the topic, even in the context of providing a framework for the subject.

The Pinstrup-Anderson article identifies and discusses three factors influencing the effect of food and nutrition programs on levels of nutrition:

The reviewer is an economist with the International Economics Division, ERS.

(1) the ability of households with malnourished members to acquire food, (2) the food acquisition behavior of households, and (3) the intra-household distribution of food.

The articles by Chen and by Gencaga present interesting econometric results. Chen was unable to discover a significant relationship between "child caloric intake" as the dependent variable and per-capita household consumption and wealth as independent variables. Gencaga was similarly unable to identify a significant relationship between income and the consumption of protein and calories, except for the top 10 percent of the population. A hypothesized explanation for these surprising results is that the household is not the appropriate unit to work with, but rather some larger community concept, such as the village, given the presence of intra-community transfers of food.

The section on "Political Aspects of Food Policy" contains three chapters concerned with political obstacles to reforming food policies in developing countries. Selowsky argues that development assistance packages should be designed to help bridge the financial gap between those who benefit from a policy reform and those who are hurt by it, thereby creating broader political support for reform.

The centerpiece of this section, and it could be argued of the book, is the article by Bates, which summarizes the impact of political interests on the formulation of economic policy. Bates defines agricultural policy as those decisions taken by "governments that influence the prices farmers confront in the markets which determine their incomes." The central issue is why government policy tends to discriminate against farmers in countries where agricultural interests predominate? Bates portrays governments as seeking to retain power and therefore, concerned with implementing policy that serves the best interests of influential constituents and that undermines the interests of opposition groups. For example, Bates argues that governments seeking to increase food production will favor project-based policies over price-based policies, even though improved price policies are usually a necessary condition for projects to succeed. Price policies encounter strong and cohesive opposition from urban interests, whereas project-oriented policies allow the political elite greater opportunities for job distribution. The Bates model is a useful framework in which to view the policy formulation process.

Delehanty provides a valuable perspective on food policy reform by arguing that it should be approached through "negotiation of political contracts which redistribute the economic rents created by public policy." These rents are simply "opportunities to buy for less or sell for more than would be the case in the absence of government intervention." Delehanty's view, especially when combined with Bates' model, opens the door to some intriguing and innovative multilateral and bilateral aid policies. However, the editors do not explore these possibilities.

The final section in the first part of the book covers trade aspects of food policy. Donaldson reviews food security events since the 1972-74 crisis, pointing out that this crisis was a historical anomaly. World food supplies have "consistently outstripped population for a hundred years." Donaldson lists several factors that need to be considered when addressing food security issues, for example, distribution systems, price policy, protection of low-income households, and production technology. He argues that the key to improving food security "lies in increasing the incomes of low productivity groups and increasing the efficiency of the distribution systems which serve them."

Schuh clearly and succinctly analyzes how the roles of agriculture and trade have changed in the promotion of economic development. He argues that the international economic system has changed in many ways, including the emergence of a more fully integrated capital market, flexible exchange rates, and economic liberalization by the less developed countries. Furthermore, he argues that many international institutions designed to meet the needs of developed countries have become irrelevant as the developing countries have assumed a greater economic importance. Schuh sees two broad areas that need attention: (1) a new set of institutions to deal with world problems, especially in the areas of international monetary reserves and arrangements governing trade, and (2) more research on the ways the world economy has changed.

The last half of this volume deals with more specific issues concerning the development of national food policy capabilities and with case studies of food policy projects in Thailand, Kenya, and Tunisia. These last sections are interesting, but to a fairly limited audience. These sections tend to be brief and do not offer the level of detail in which a country expert would be interested.

Little in the book is new; most articles are condensed versions of previous research. Therefore, the book is most useful for readers interested in an overview of food policy topics. Those who are interested in more detail may feel dissatisfied with both the quantity and quality of the articles.

American
Journal of
Agricultural
Economics

Edited by Richard E. Just and Gordon C. Rausser

Published by the American Agricultural Economics Association

Articles: Bredahl, Schmitz, and Hillman, "Rent Seeking in International Trade: The Great Tomato War"; Caswell, "Dominant Forms of Corporate Control in the U.S. Agribusiness Sector"; Zanias, "Adjustment Costs and Rational Expectations: An Application to a Tobacco Export Model"; Thurman, "The Poultry Market: Demand Stability and Industry Structure"; Hauser and Andersen, "Hedging with Options under Variance Uncertainty: An Illustration of Pricing New Crop Soybeans"; Thompson and Bond, "Offshore Commodity Hedging under Floating Exchange Rates"; Olmstead and Wooten, "Bee Pollination and Productivity Growth: The Case of Alfalfa"; Reid and Bradford, "A Farm Firm Model of Machinery Investment Decisions"; Romero, Amador, and Barco, "Multiple Objectives in Agricutural Planning: A Compromise Programming Application"; McSweeny, Kenyon, and Kramer, "Toward an Appropriate Measure of Uncertainty in a Risk Programming Model"; Knapp, "Dynamic Equilibrium in Markets for Perennial Crops"; Train and Strebel, "Energy Conservation and Rebates in Commercial Food Enterprises"; Franklin, Harrell, and Lenard, "Income Effects of Donated Commodities in Rural Panama"; McGuckin, Mapel, Lansford, and Sammis, "Optimal Control of Irrigation Using a Random Time Frame"; Chapman, "Computation Techniques for Intertemporal Allocation of Natural Resources"; Centner and Wetzstein, "Reducing Moral Hazard Associated with Implied Warranties of Animal Health"; Bewley and Young, "Applying Theil's Multinomial Extension of the Linear Logit Model to Meat Expenditure Data"; Stefanou, "Technical Change, Uncertainty, and Investment"; Dahlgran, "Agricultural Economists in the Information Age: Awareness, Usage, and Attitudes Toward Electronic Bibliographic Databases"; Barry, "A Note from the Editor"; plus other Articles and Book Reviews.

Annual membership dues (including Journal) $45; Annual subscription rate $65. Contact Sydney James, Department of Economics, Iowa State University, Ames, Iowa 50010. Published in February, May, August, November, and December.

A NEW INTERNATIONAL JOURNAL!

AGRICULTURAL ECONOMICS

The journal of the International Association of Agricultural Economists

Editor-in-Chief:
Dr. Douglas D. Hedley,
Jakarta, Indonesia

AGRICULTURAL ECONOMICS

The Journal of the International Association of Agricultural Economists

IAAE

Elsevier

Policy of the Journal

Agricultural Economics is a new international journal devoted to serving the interests not only of the International Association of Agricultural Economics (IAAE), but also of agricultural economists all over the world. The journal will provide a focal point for the publication of work on research, extension and out-reach, consulting, advising, entrepreneurship, administration and teaching, in the following areas of agricultural economics:

- **disciplinary work** - improvement of theories, techniques and descriptive knowledge of economics and its contributing disciplines such as statistics, mathematics, and philosophy;
- **multi-disciplinary subject matter areas** - energy, technical change, institutional change, natural resources, farm management, rural communities, marketing, human development and the environment, areas which are important to organised groups of public and private decision-makers facing well-defined sets of problems;
- **problem solving** - the definition, solution and management of specific practical problems.

All of these may require knowledge of values, non-monetary as well as monetary. The Editorial Board represents the world's different geographic regions to ensure that manuscripts relevant to the agriculture and membership of each region are included.

First Issue Now Available

Request order form from:
ELSEVIER SCIENCE PUBLISHING CO. INC.
P.O. Box 1663, Grand Central Station, New York, NY 10163

You can have the
Economic Research Service Database
at your fingertips

ERS has developed a series of computerized databases covering important elements of today's agribusiness and related activities here and abroad. These databases, for sale from ERS in a variety of formats, will be of considerable interest to those associated with government, commercial, and university projects.

For more information on the individual series, contact the individuals below.

Agricultural Outlook Yearbook	Evelyn Blazer	(202) 786-3313
Farm Income	Gary Lucier	(202) 786-1809
Farm Real Estate	Gene Wunderlich	(202) 786-1425
Irrigated Farms	John Hanchar	(202) 786-1410
Land Improvement Tax Simulator	Ralph Heimlich	(202) 786-1419
Pesticide Use and Management	Herman Delvo	(202) 786-1456
Fertilizer Use	Harry Vroomen	(202) 786-1456
Farm Machinery Statistics	Mike Hanthorn	(202) 786-1841
Poultry and Egg Statistics	Allen Baker	(202) 786-1830
U.S. Dry Beans	Neilson Conklin	(202) 786-1766
Food, Beverages, and Tobacco	Penni Korb	(202) 786-1624
Policy Impact Codes	Peggy Ross	(202) 786-3338
Local Government Finances	Rick Reeder	(202) 786-1544
Rural Fire Protection Facilities	Norman Reid	(202) 786-1542
Exchange Rates	David Stallings	(202) 786-1624
World Production	David Stallings	(202) 786-1624
Cameroon's Grain	Mike Kurtzig	(202) 786-1680
Egypt's Grain	John Parker	(202) 786-1681
Israel's Grain	Mike Kurtzig	(202) 786-1680
Madagascar's Grain	Mike Kurtzig	(202) 786-1680
Nigerian Grain	Margaret Missiaen	(202) 786-1681
Saudi Arabia's Grain	Mike Kurtzig	(202) 786-1680
Turkey's Grain	Mike Kurtzig	(202) 786-1680
U.S. PL 480 and Other Concessional Exports	Penni Korb	(202) 786-1624

☆U.S. Government Printing Office : 1987 - 180-917/60190

Suggestions for Submitting Manuscripts for *Agricultural Economics Research*

Contributors can expedite reviewing and printing of their articles by doing these things:

1. SOURCE. Indicate in a memorandum how the material submitted is related to the economic research program of the U.S. Department of Agriculture and its cooperating agencies. State your own connection with the program.
2. CLEARANCE. Obtain any approval required in your own agency or institution before sending your manuscript to one of the editors of *Agricultural Economics Research.* Attach a copy of such approval to the manuscript.
3. ORIGINALITY OF MATERIAL. It is our policy to print original material. We consider alternative treatments of material published elsewhere, but such treatments need to differ substantially from the original approach. When submitting your manuscript, identify, if applicable, related material either published or submitted for publication.
4. ABSTRACT. Include an abstract and at least three keywords when you submit your article. The abstract should not exceed 100 words. It should report the major findings of your research.
5. NUMBER OF COPIES. Submit three good copies.
6. TYPING. Double space everything, including abstract, footnotes, and references.
7. FOOTNOTES. Number consecutively throughout the article.
8. REFERENCES. Check all references carefully for accuracy and completeness.
9. CHARTS AND OTHER ARTWORK. Use charts sparingly. Keep design as simple as possible. Submit all artwork in draft rather than in final form, accompanied by neatly prepared pages with essential data for replotting.

Researchers interested in a bibliography arranged alphabetically by author of materials in *Agricultural Economics Research* from the first issue in 1949 through the current issue should write Gerald Schluter, Economist, ERS/ARED, U.S. Department of Agriculture, Washington, DC 20005-4788.

Readers interested in a chronological bibliography of materials in *Agricultural Economics Research* from the first issue in 1949 through the last issue in 1979 should write Gerald Schluter, Economist, ERS/ARED, U.S. Department of Agriculture, Washington, DC 20005-4788.

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
1301 NEW YORK AVENUE, NW.
WASHINGTON, D. C. 20005-4788

BULK RATE
POSTAGE & FEES PAID
USDA
PERMIT NO. G-145